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Accounting for Water Supply and Demand

An Application of Computer Program WEAP to the Upper Chattahoochee River Basin, Georgia

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INTRODUCTION TO THE STUDY

Background to the Research

Understanding the balance, or imbalance, of all water supplies and demands in a region is a necessary first step toward effective water resource planning and management. Most water resource planning studies whether local, state, or federal address only part of the water picture. They commonly focus on a reservoir, or reservoir system, on a river and reservoir, or on a groundwater aquifer. A comprehensive and integrated picture of all of a region's supply and use, both present and future, is not usually created. The task of developing a water balance, or water budget as it is sometimes called, has been the subject of research at the Hydrologic Engineering Center for a number of years (Hayes, et al., 1980). The content, guidelines and computer programs for water balance analysis have been investigated to find effective ways to define and conduct these studies. This document reports on a research project to investigate the capability of the computer program Water Evaluation and Planning System (WEAP) developed by the Stockholm Environment Institute-Boston, Tellus Institute, to model all supplies and demand in a region and to provide information on the balance, or imbalance, of the water resources under a variety of future conditions. The program was applied to the upper Chattahoochee River Basin, Georgia to test its capability. A number of desirable additions to the program were identified to make it more suitable for Corps-wide use and these were made through a contract between the Hydrologic Engineering Center and the Tellus Institute.

This training document has three objectives. First, to illustrate the capability of the WEAP program to account for all supply and demand in a water balance analysis. Second, to provide a WEAP user with a document that illustrates how the program is applied to a multiple-use watershed with a major river and reservoir and to pass on the experience gained in this effort. Third, to offer observations on the application to the upper Chattahoochee River Basin, Georgia.

The remainder of the introduction briefly describes the A-C-F and upper Chattahoochee River Basins, some of the water resource issues, and how WEAP can help to answer important questions and understand the critical interrelationships of water use and supply in this basin.

Upper Chattahoochee River Basin

The upper Chattahoochee River is the uppermost part of the Apalachicola-Chattahoochee-Flint (A-C-F) River Basin which includes parts of Georgia, Alabama and Florida (Figure 1). Starting in the headwaters of Habersham County in northeastern Georgia, the Chattahoochee River flows southwest past Atlanta until it reaches the border with Alabama at West Point. Here it turns southward and forms the border between Georgia and Alabama down to Florida. At Lake Seminole the Chattahoochee is joined by the Flint from the east. The outflow from Lake

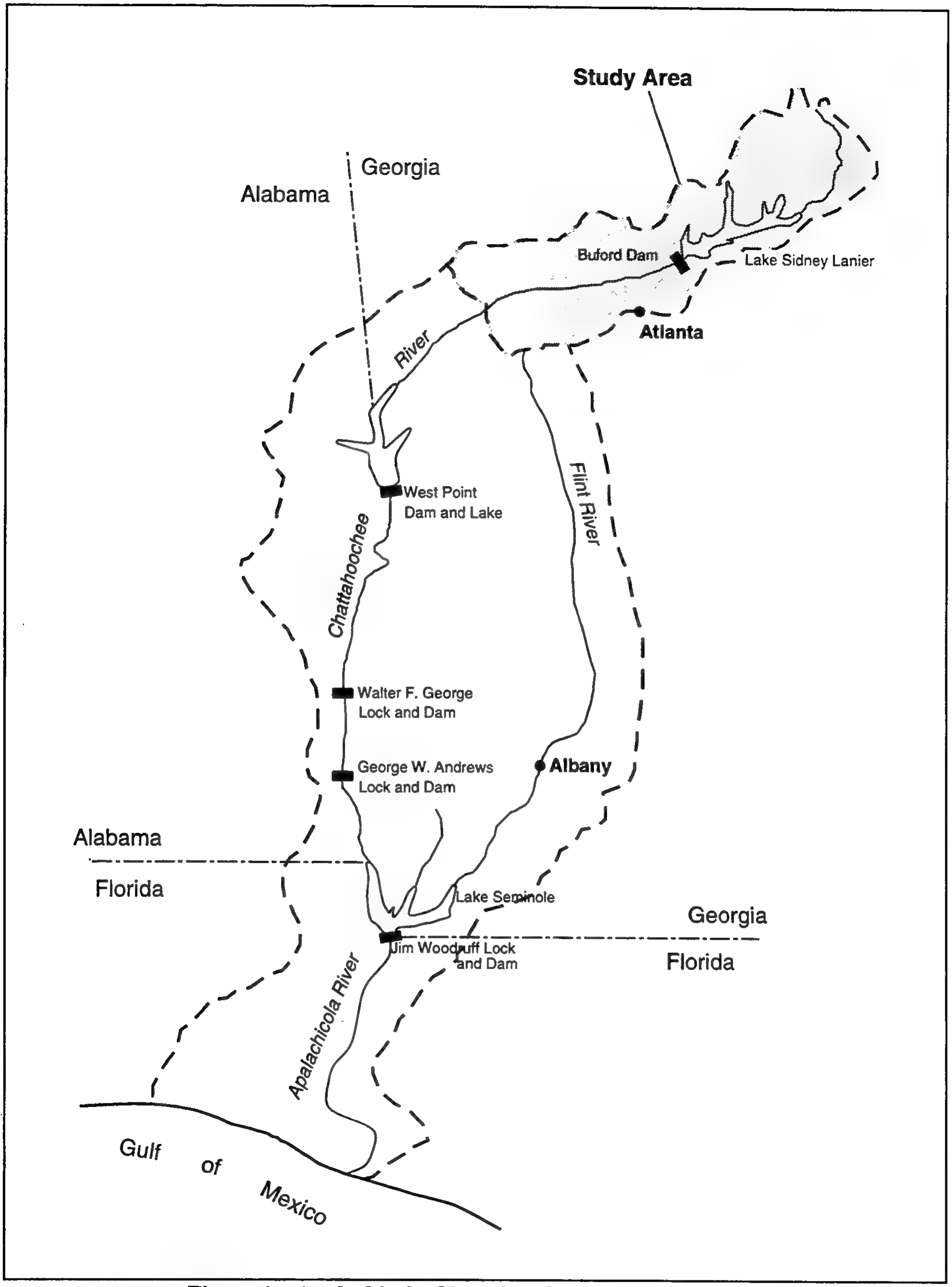


Figure 1: Apalachicola-Chattahoochee-Flint River Basin

Seminole at Jim Woodruff Dam on the border between Georgia and Florida becomes the Apalachicola River. The Apalachicola flows southward through northwestern Florida and into the Apalachicola Bay.

The A-C-F system is an important water resource system in the Southeastern United States, providing water for 1) municipal uses in the growing Atlanta Metropolitan Area (AMA) and in other smaller communities along both the Chattahoochee and Flint Rivers; 2) hydropower at three major dam sites and other locations; 3) navigation in the lower portions of the system; 4) recreational uses throughout; 5) important environmental concerns including fish and wildlife survival, ecology of Apalachicola Bay, and water quality downstream of AMA; and 6) industrial growth expected in southeastern Alabama and southwestern Georgia.

During the 1980's the A-C-F River Basin experienced two of the worst droughts in recent history. Serious conflicts among competing uses for water arose, and severe actions were necessary to manage the scarce resources during this period. This experience pointed to a need to examine the water resources in a comprehensive and integrated way.

This study is concerned with the uppermost portion of the A-C-F Basin from the beginning of the Chattahoochee watershed above Lake Sidney Lanier down to approximately 24 km (15 miles) below Atlanta (Figure 2). This portion was selected because it had several features of major importance to the A-C-F Basin, the city of Atlanta, the major metropolitan area of the region; Lake Sidney Lanier, an important multiple-purpose reservoir; and municipal, commercial, industrial and agricultural uses in both urban and rural areas. At the same time the study area is not so large that it cannot be investigated as a research project.

Planning Questions that WEAP Can Help Answer

WEAP gives a holistic, integrated picture of the supply and demand system of the study area at any point in time, and under different user-specified sets of conditions. This picture includes supplies available from rivers, creeks, reservoirs, and groundwater and demand needed for water withdrawals, discharges, and instream flow requirements. Unlike traditional river/reservoir simulation models which are limited to the water resources of a river or reservoir, WEAP creates a picture of all the water resources of the study area and their consumptive and non-consumptive demands. WEAP is rich in technical detail of the water system.

WEAP operates on the basic principle of water balance accounting where different sets of conditions, on either the supply side, the demand side, or both can be investigated. For example, the effects of: changing hydrologic conditions and the occurrence of droughts, different future water requirements, changing the location of a river withdrawal point and/or its quantity, raising or lowering a reservoir conservation pool or buffer zone, or increasing instream flow requirements, can be quickly and easily examined in WEAP. The user, through this kind of investigation of the behavior of the total system, begins to develop a good understanding of the impacts of present and proposed actions on different parts of the system. The relationships, tradeoffs and conflicts between different water uses are highlighted and quantified in the WEAP water accounting picture.

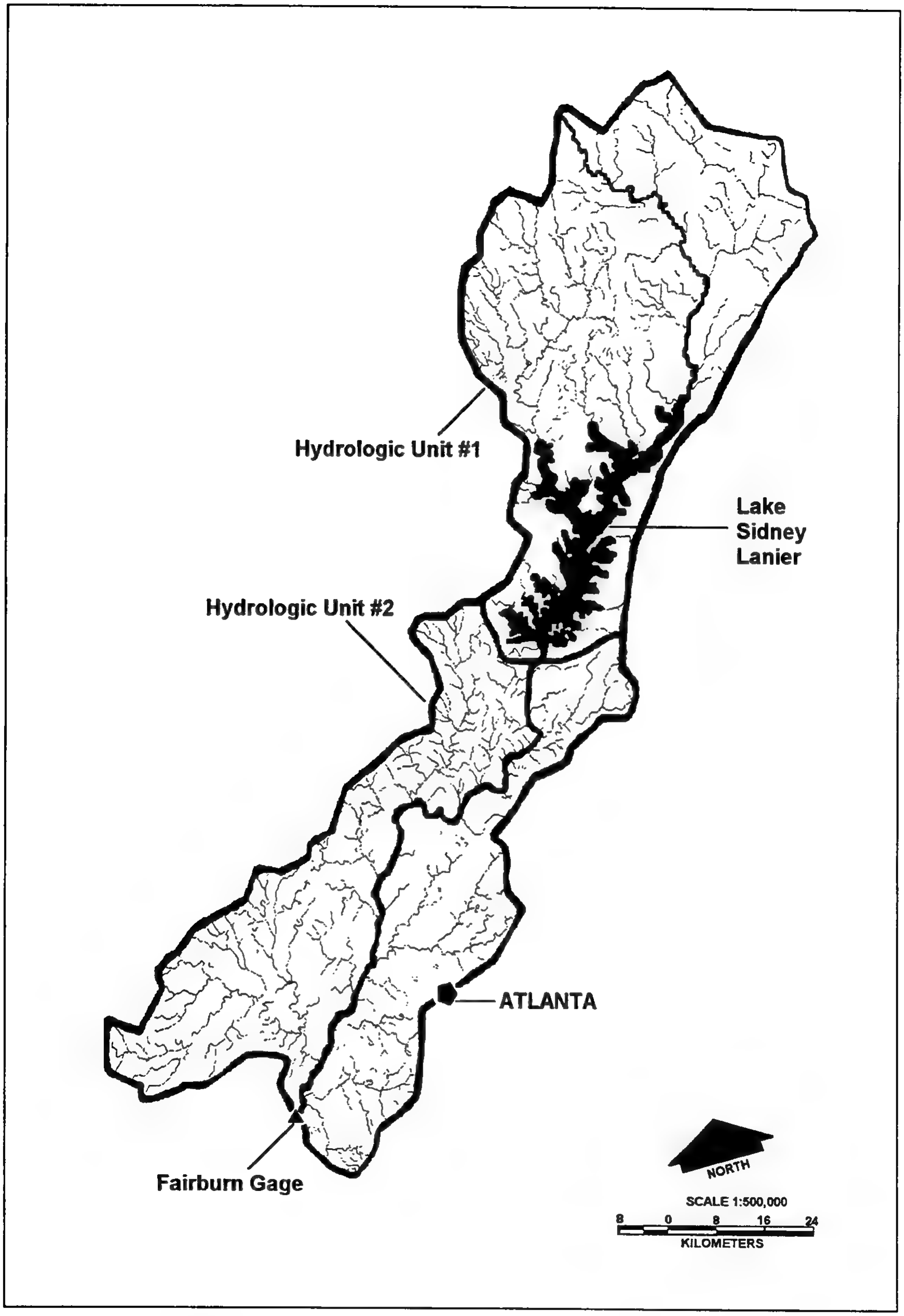


Figure 2: Study Area - Upper Chattahoochee River Basin (adapted from Georgia Department of Natural Resources, 1984)

In the upper Chattahoochee Basin, there is concern over the impacts of present and future projected levels of water use in the Atlanta Metropolitan Area (AMA) on the river basin resources. The heart of the matter is the need for planning and management under drought conditions. In WEAP, a unified relational database for all water users, operating purposes, and water supply resources can be configured, stored, modified or updated, and accessed and "run" at any point to see the water balance situation for the whole system. Alternative scenarios of future supply and demand can be easily evaluated. By operating the system at different use levels and with priority for different purposes, the WEAP user gains greater understanding of the existing system, the points of conflict, problem areas, and develops insights and actual proposals for better planning and management strategies relative to the needs and desires of all water users in the system.

As the Atlanta Metropolitan Area and other water needs grow, withdrawal and discharge permitting decisions will have to be made. WEAP, with its integrated water accounting database structure, can be used for such real-time planning issues as: the examination of existing permit levels against current actual demand-generated use and discharge levels; the evaluation of whether to permit increased withdrawal or discharge levels at existing sites; the evaluation of potential new permit withdrawal points and their appropriate level with respect to other purposes in the system. WEAP can also be used to investigate the relationship between reservoir operation and system demands, water transfers into and out of the study area, possible new structures for storage or flow regulation, re-allocation of reservoir storage, and the effects of municipal and industrial water conservation practices.

Because the WEAP model is very transparent to the user, operates as a simulation model, and is based on relatively simple water balance accounting principles, it can support another important function for the upper Chattahoochee study and for the decision-making process. That role is as a tool for all the different parties involved in watershed management to evaluate and negotiate the options, policies and proposals from a common framework of data, assumptions, and terminology. The model is built upon detailed data familiar to the different water agencies: reservoir and river data from the Corps of Engineers, permit data from the state of Georgia, demand site and demand projections from the Atlanta Regional Commission, and streamflow data from the U. S. Geological Survey. With these data in the WEAP model, the outcomes and consequences of alternative operations can be verified and easily communicated among the group of players in the decision-making process. This facilitates open and concrete discussions about alternatives and impacts.

Overview of the Application

This report covers the development of the WEAP application. The data used and how the data is interpreted and developed to fit the requirements of the WEAP model (the why's, how's and what's of fitting the upper Chattahoochee Study to the WEAP model). The report includes screens from the WEAP menu to demonstrate how the study is built-up in the WEAP model.

The time and effort for this research investigation were concentrated on developing the application and not on primary data collection. Water use and supply data already compiled and available from existing studies and reports have been used (see the References and Appendix A - Data Sources). Some of the water use data reflects projections and estimates which have been

made by water agencies for future water demand. Use of available data and the excellent cooperation of the water agencies allowed the application to be developed quickly and easily. For those concerned with questions not specifically addressed in this study, changes and different assumptions can easily be made to the WEAP model.

An inventory of the water supply and demand features modeled in the upper Chattahoochee study are presented in Table 1 and are discussed in detail in the subsequent sections of this report.

Table 1
Inventory of Supply and Demand Features in the Upper Chattahoochee River Study Area

Study Area

- 16 Counties
- 2 Hydrologic Units (HU #1 and #2)
- 1 Sub-basin (Lake Sidney Lanier to Fairburn Gage)
- 25 River Reaches (River Segments between Two Nodes)

River Supply

- 1 Main River (Upper Chattahoochee River)
- 1 Main River Reservoir (Lake Sidney Lanier)
- 2 Hydroelectric Power Plants (Lake Sidney Lanier and Morgan Falls)
- 1 Tributary (Sweetwater, Cr.)
- 11 Confluences
  - 4 Gaged Streams (Suwanee Cr., Big Cr., Sope Cr., Peachtree Cr.)
  - 6 Ungaged "Local" Streams (Norcross, Roswell, Morgan Falls, Atlanta, Hwy 280, Fairburn)
- 13 Withdrawal Nodes
  - 8 Withdrawal and Return Flow (US Suwanee Cr., DS Johns Cr., Holcomb Br. Rd., Roswell Rd. Br., Johnson Ferry Rd., US Peachtree Cr., Jackson Pkwy., Cambellton Rt. 166)
  - 5 Return Flow Only (Wilson Cr., Marietta Blvd., Hwy 20, Cobb/Douglas Co. Line, Sweetwater Cr./Camp Cr. Wastewater Plants)
- 4 Instream Flow Requirements (Water Quality-1, Water Quality-2, Fish and Wildlife, Water Quality-3)
- 1 Minimum Downstream Requirement (Fairburn Gage)

Local Supply

- 5 "Other" Sources (Soque River, Turner Cr., Camp Cr., Yahoola Cr., Sweetwater Cr.)
- 1 Groundwater Source (Blue Ridge/Piedmont Aquifer)
- 0 Local Reservoirs
- 1 Out-of-Basin Source (Lake Allatoona)
- 1 Unaccounted Surface Water Source

Demand Sites

- 24 Demand Sites
  - 12 Countries
  - 12 Individual Sites
- 44 Transmission Links
- 10 Return Links

Demand Branches

- 3 Sectors (Municipal/Commercial; Industrial; Agricultural)
- 30 Subsectors (16 Countries; 4 Industries and Counties; 12 Counties)
- 56 End-uses (34 Urban, Rural, Plants; 9 Plants and Counties; 13 Hydrologic Units)
- 84 Water Devices (54 Plants and All; 17 Plants and Cities; 13 All)

Demand Projections

- 1 Base Year (1990)
- 2 Future Years (Years 1995 and 1999 for the AMA)
- 2 Growth Rates (4.94% for other then AMA Demand; 2.22% for Wastewater Return)

SETTING UP THE MODEL

All the components of the water resource system under study, and the parameters of the analysis to be undertaken, are defined in the SETUP portion of WEAP. There are four primary types of system components in WEAP: *demand sites*, thought of as a related set of water distribution systems; *local supplies,* or non-river based water supply components, each one managed and operated independently; *wastewater treatment facilities* which receive water after it is used and returns it to the main river or groundwater, and *rivers and their nodes*, representing the water resources and other river-based water uses that form a single river network managed together through a river simulation mode. Once the components are defined, the user then configures the water system by linking demand sites with local supplies and/or river nodes. Links provide the ability to allocate water to a demand site from a water source point. In the water balance accounting or calculation part of WEAP, water is sent out or transmitted over the system links on a monthly basis to the appropriate demand sites to satisfy their demands. This is the fundamental structure of the WEAP program. Of course, rules are needed to control the way water is managed for each component and the way water is allocated across the system links. The WEAP water management and allocation rules will be described and discussed in the context of this application case study as they are encountered in developing the system.

In the other program modules, all data entry and analysis results are structured by and attached to the components the user chooses to define in SETUP. Therefore, the SETUP in the WEAP modeling program is the most important step. At any point along the analysis you can modify your system structure by going back into SETUP and adding, deleting, moving, changing, editing and re-linking components. However, some types of system changes will require that you also make appropriate modifications to various data entered in other program modules of WEAP. Because this can get rather involved for complex systems, it is best to make every effort to thoroughly think through the system configuration before delving too deeply into data entry for other modules.

Getting Started

Before entering information and data into WEAP, the following aspects of the study must be decided:

<u>Boundaries and Definition of the Study Area.</u> A study area can be a set of demand sites defined by political boundaries or by geographic boundaries. It can also be defined as a specific water supply system such as a river basin or a groundwater aquifer. In one case the point of focus will be the demand sites, while in another it will be the water supplies in a region of interest. In other cases it may be necessary to conceive of both a set of demand sites and the specific river system together as the study area. Whichever the user chooses, ultimately in WEAP the 'study area' will contain a distinct set of information and assumptions about a system of linked demands and supplies. Several different 'study areas' as defined in the WEAP program could actually be used to represent the same geographic area or watershed, each under alternative configurations, or different sets of demand data or operating assumptions. In this way 'study areas' can be thought of as representing separate databases where different sets of water supply

and demand data are stored, managed and analyzed. Additional guidance on selecting the study area is in the section on "Understanding the Operating Criteria."

In the application of WEAP to the upper Chattahoochee Basin, the 'study area' is limited to the headwaters of the watershed above Lake Sidney Lanier to the USGS gage 02337170 at Fairburn in Fulton County (river mile 281.8 from the confluence of the Flint and Chattahoochee Rivers). The area covers 5335 sq. km. (2060 square miles); 2694 sq. km. (1040 square miles) of which is above Sidney Lanier.

The 'study area' is also defined as all demand sites associated with the portions of counties that fall within the watershed area, as well as any demand sites outside the watershed boundary that receive surface water directly from within the study area. Portions of sixteen Georgia counties make up the study area (Figure 3 and Table 2). The last four counties in Table 2, while completely outside the river basin boundary, contain portions of the Atlanta Metropolitan Area (AMA) whose water demands are served by Fulton County supply systems withdrawing water directly from the Chattahoochee River in the study area. Parts of several other counties falling outside the watershed area are also included in the study area because their area's municipal water demands are serviced by Atlanta area water supply systems whose location and water supply source is inside the study area. The distinction between counties in and out of the study area boundaries and those in and out of the AMA is illustrated in Figure 4. In effect the study area boundaries have become somewhat more flexible than the rigid definition of the hydrologic boundaries in order to include the adjacent demand areas served by water supplies from within the hydrologic supply system.

Base Year for Water Demand Data. The base year is the year for which good demand data are available and from which future forecast of demand can be made. It also can be thought of as the most current and up-to-date year for water use/demand information, and as the beginning year of the period of analysis.

The base year in the Chattahoochee study is 1990. Four sets of 1990 water use data were used to develop the base year demand data for the WEAP application; one set is from the 1990 Plant Production Summary (Georgia Department of Natural Resources, 1993), and the second is a set of projections for 1990 water use in the study area made in 1984 (Georgia Department of Natural Resources, 1984). Information on transfers from the primary withdrawal facilities was taken from the Atlanta Regional Water Supply Plan (Atlanta Regional Commission, 1991). Wastewater return flow figures were extracted from the USGS 1990 Water Use Data Base for counties in Georgia (U.S. Geological Survey, 1993). These four sets of demand data were organized and integrated into a single 'study area' in WEAP.

Period of Analysis. A continuous monthly analysis is performed for each year specified for the period of analysis. The period starts with the base year and goes to the last year entered. An intermediate year is specified when it is desired to change the growth rates for projecting water demands during the period of analysis. Sixty years is the upper limit on the total number of years in the analysis. Calculation run times for WEAP will increase in proportion to the number of years. The reporting years are a subset of the years in the analysis and represent the years in which the user wants to see results. The reporting years are easily changed in WEAP without having to rerun the program. Results from any or all years can be specified, as long as the years are within the limits defined in the period of analysis.

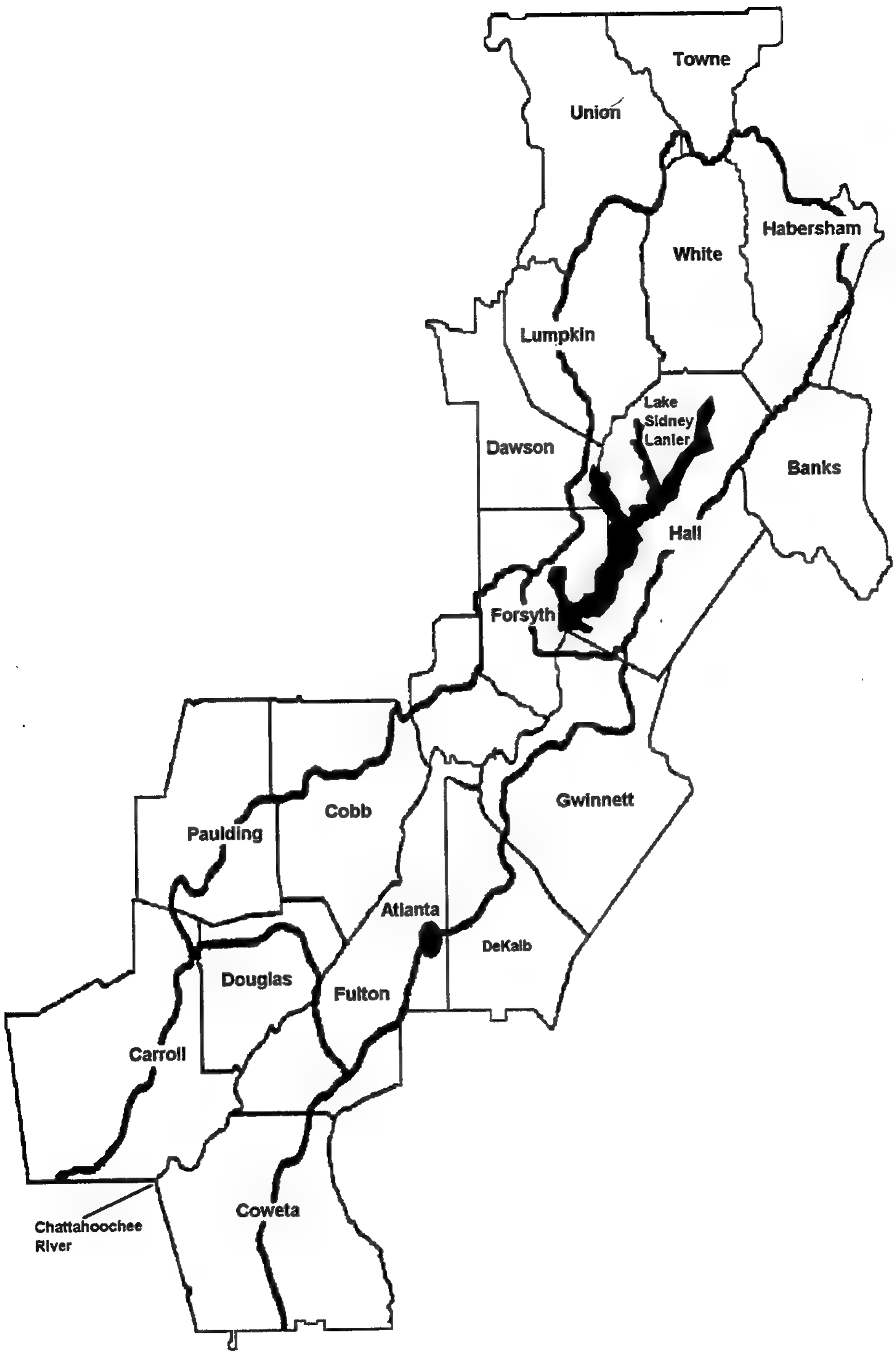


Figure 3: Counties of the Upper Chattahoochee River Basin (adapted from Georgia Department of Natural Resources, 1984)

Table 2
Georgia Counties in the Upper Chattahoochee Study Area

County	% of County in HU 1[1]	% of County in HU 2[1]	Total Percentage of County in the WEAP Study Area
Habersham	80		80
White	100		100
Lumpkin	60		60
Hall	60		60
Dawson	10		10
Forsyth	30	40	70
Gwinnett[2]		20	20
DeKalb[2]		30	30
Fulton[2]		60	60
Cobb[2]		60	60
Douglas[2]		40	40
Paulding		30	30
Clayton[2]			0
Rockdale[2]			0
Henry[2]			0
Fayette[2]			0

Source: Georgia Department of Natural Resources, 1984, p.79.

[1] HU refers to hydrologic (sub) units of the Chattahoochee River as defined in the source report. HU 1 ends at Buford Dam, and HU 2 ends at the USGS Fairburn Gage. These hydrologic units do not correspond to the equivalent USGS hydrologic subunit boundaries for the Chattahoochee River. The percentage of county refers only to the actual land area inside the HU boundary.

[2] The portions of the Atlanta Metropolitan Area and adjacent suburbs that fall within these counties, but outside the hydrologic boundaries of the study area, are included in the study if they are part of the service areas of the Atlanta Metropolitan Area municipal water distribution systems that withdraw surface water from within the study boundaries. Later sections of this report deal more fully with this aspect.

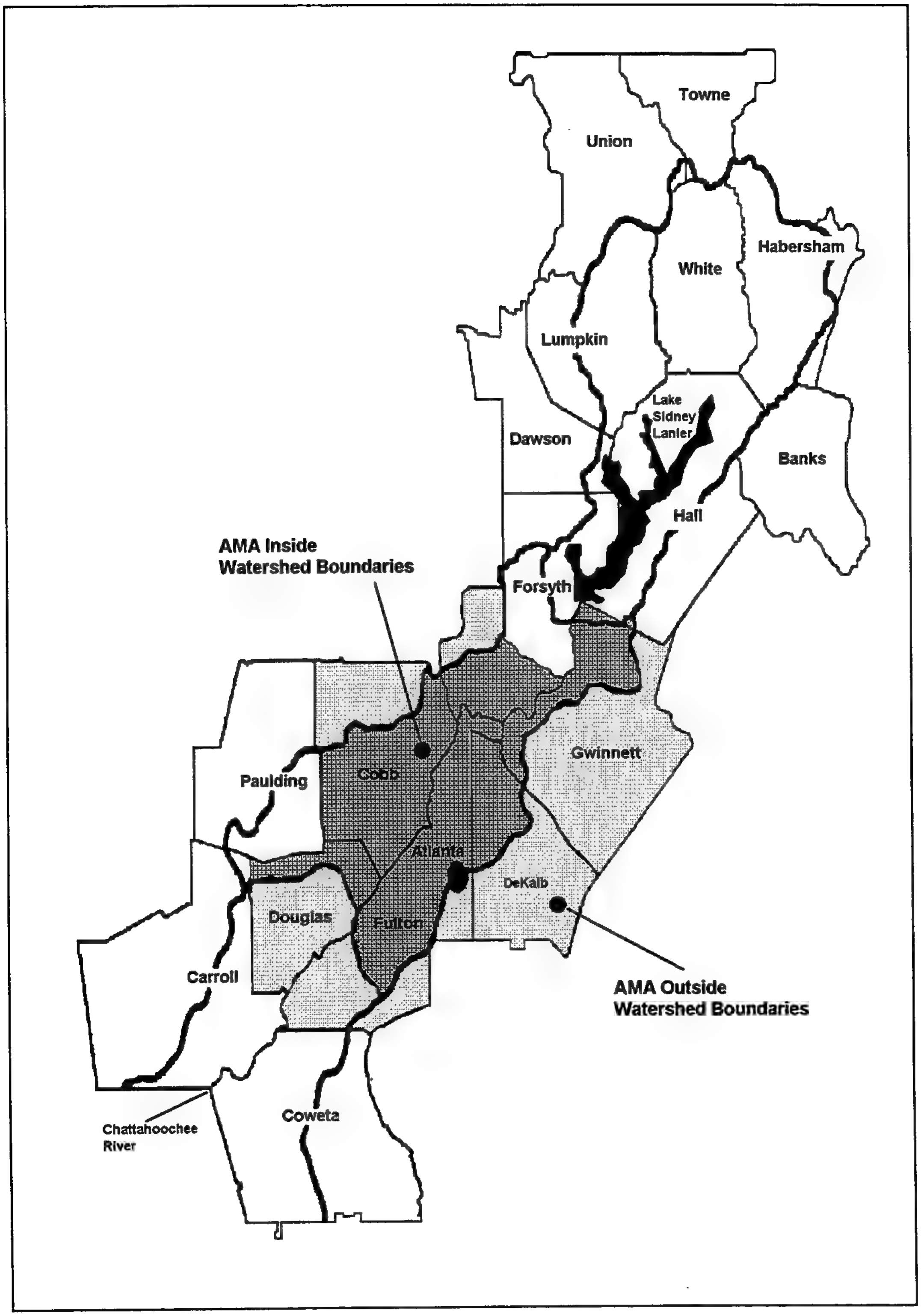


Figure 4: Atlanta Metropolitan Area (AMA) - Upper Chattahoochee River Basin

In the upper Chattahoochee River Basin a critical period of record for managing water supplies was during the 1980's when two serious droughts occurred. One important reason for using WEAP is to examine the performance of the water system under these historical drought conditions at both current (1990) and future water use levels in the years (1995, 1999). Thus, the period of analysis is a 10-year period of demand growth (Figure 5). The 10-year historical streamflow conditions from 1980 to 1989 were used for the hydrology. The base year, year 1995, and year 1999 demand levels are analyzed with these hydrologic conditions.

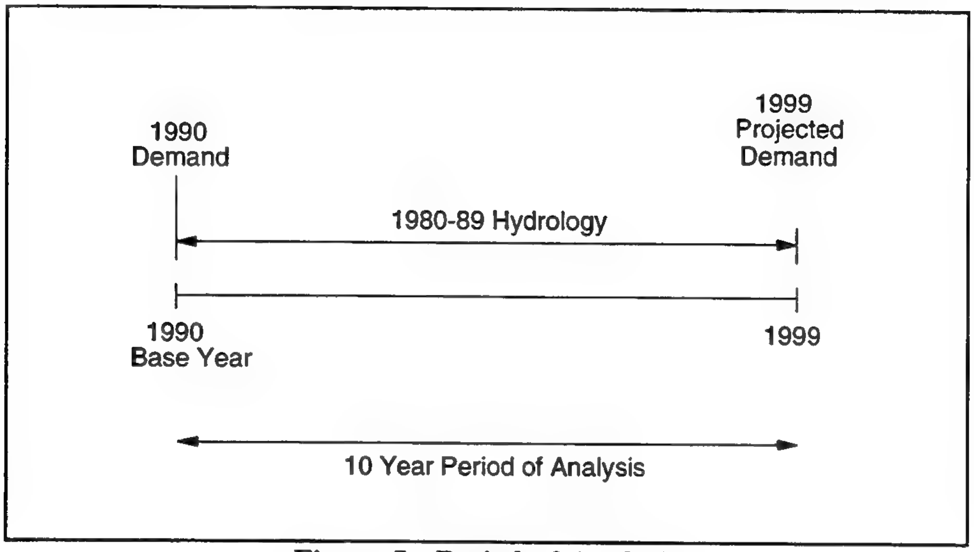


Figure 5: Period of Analysis

<u>Selecting a Hydrology.</u> The watershed hydrology is defined by monthly streamflow at river and local nodes in the riverine system. This is illustrated in Figure 6. Streamflow data are required at the headflow location on the main river, at all tributary and confluence nodes and where demand sites withdraw water from local "other" creeks and streams. The confluence nodes may represent gaged streams coming into the main river or ungaged "local" runoff.

In WEAP, the user may choose between using "historical" streamflow records or "hydrologic fluctuations" of normal year data. The decision will depend on if you want to perform continuous simulation analysis over some critical historical period or whether you want to test a hypothetical event or set of events. In the former case, the user must have enough historical data to develop a set of monthly records for all streamflows and surface water supply points in your water system. In using historical data, the user prepares flow data files for each surface water input point defined in the system. Details of the historical data files can be found in Appendix D of this report and in Appendix 1 of the WEAP User Manual, 1994. These historical data files must contain data values equal to the total number of months in the analysis period for each supply point.

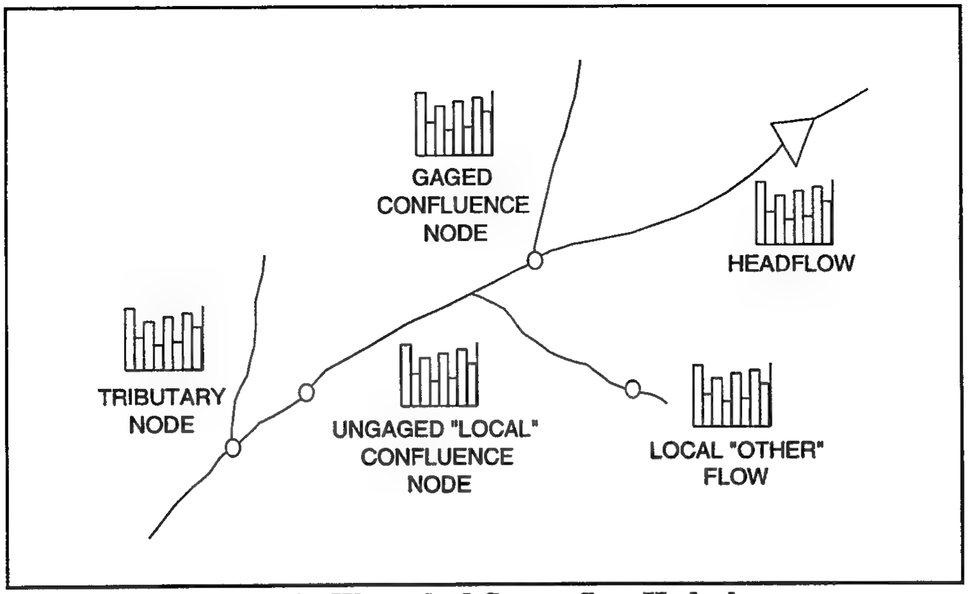


Figure 6: Watershed Streamflow Hydrology

Using "hydrologic fluctuations", the user develops a representative, or "normal", single year of monthly values for streamflow and surface water supply points in the system. With this single year of data, the user can compare supply and demand for this "normal" event, or create "wet" and "dry" year percentage monthly fluctuations and analyze other more extreme events. For example, a "dry" June might be 10 percent less than normal.

Appendix E discusses many of the methods available to develop monthly streamflow data and some of the considerations in choosing between methods.

Whether or Not to Use the River Simulation Option. Using only 'local supplies' is a simple way to account for all water supply sources, foregoing the need to model the river. However, the SUPPLY program treats each 'local supply' as predetermined and independent of any actions and conditions occurring at any other point in the system. Also, if only local supplies are used, instream flow requirements cannot be explicitly evaluated, an important feature available through the river simulation mode. If the user is interested in the operation of a river system; needs to see the interdependence of different river-based water uses, including instream flow requirements; or wants more sophisticated reservoir operating rules than those available for local reservoirs, then the River simulation mode should be used for those parts of the system that impose these types of analysis needs.

For the Chattahoochee study area, the River simulation is essential for modeling and understanding the multiple-purpose aspects of water use in the Chattahoochee River and Lake Sydney Lanier. The only way to evaluate the interdependent impacts of water management options for the Chattahoochee system on the different key water use purposes mentioned in the introduction is through the River option. When both local supplies and a main river are used, as in this study, the water resource system can be divided many different ways between these two WEAP supply options. The final configuration will again depend on objectives of the study, on

data limitations and on the different capabilities of these two supply characterizations relative to the kinds of information desired from the model application and the analysis.

Basic Types and Sources of Data

The following types of data which were collected for this demonstration study are typical of the kinds of data that will be needed for any WEAP application. Their sources in the upper Chattahoochee study are given in Appendix A - Data Sources and are indicative of possible sources for each type of data.

*existing water use studies and data (State agencies, USGS databases, county and municipal agencies, etc...)

*streamflow gage records, their locations by distance from river mouth, their period of record, their drainage area, (USGS gage lists, Corps of Engineers Mobile District Files of USGS monthly flow data for all gages in basin, Corps' distance from river mouth tables)

*historic monthly streamflow data for gaged and ungaged areas in the study area for the time horizon of the analysis, (determine ungaged contributing flow areas, estimates of volumes, to determine all natural water resource flows available)

*permitted surface and groundwater withdrawals in the study region, their distance from river mouth locations and their permitted levels, and where possible the watershed drainage areas associated with the river mile withdrawal points, the name, city and county of the permit holder. (USGS and State lists of withdrawal point permits)

*the full network of the river system and distance from river mouth locations for any rivers to be modeled, (Corps' distance from river mouth tables)

*permitted discharges, their distance from river mouth locations and quantities, the holders of the permits and the origin of discharged water in order to associate it with a distribution system as a return flow from a demand site (USGS, State discharge and permits)

*maps of the region with county boundaries, city locations, and hydrologic unit boundaries, and river system network that can be overlaid.

*basic water use data, broken down by economic sector, specific water user, etc... such as the USGS water use data bases by county.

*activity levels for cities, industries, agriculture.

Building the Model of the Water System

The SETUP program of WEAP is where the supply and demand features of the water resource system are defined and the system is configured. The principal features modeled by WEAP are shown in Figure 7. The elements should be defined in such a way as to adequately describe the water system to answer the questions identified previously.

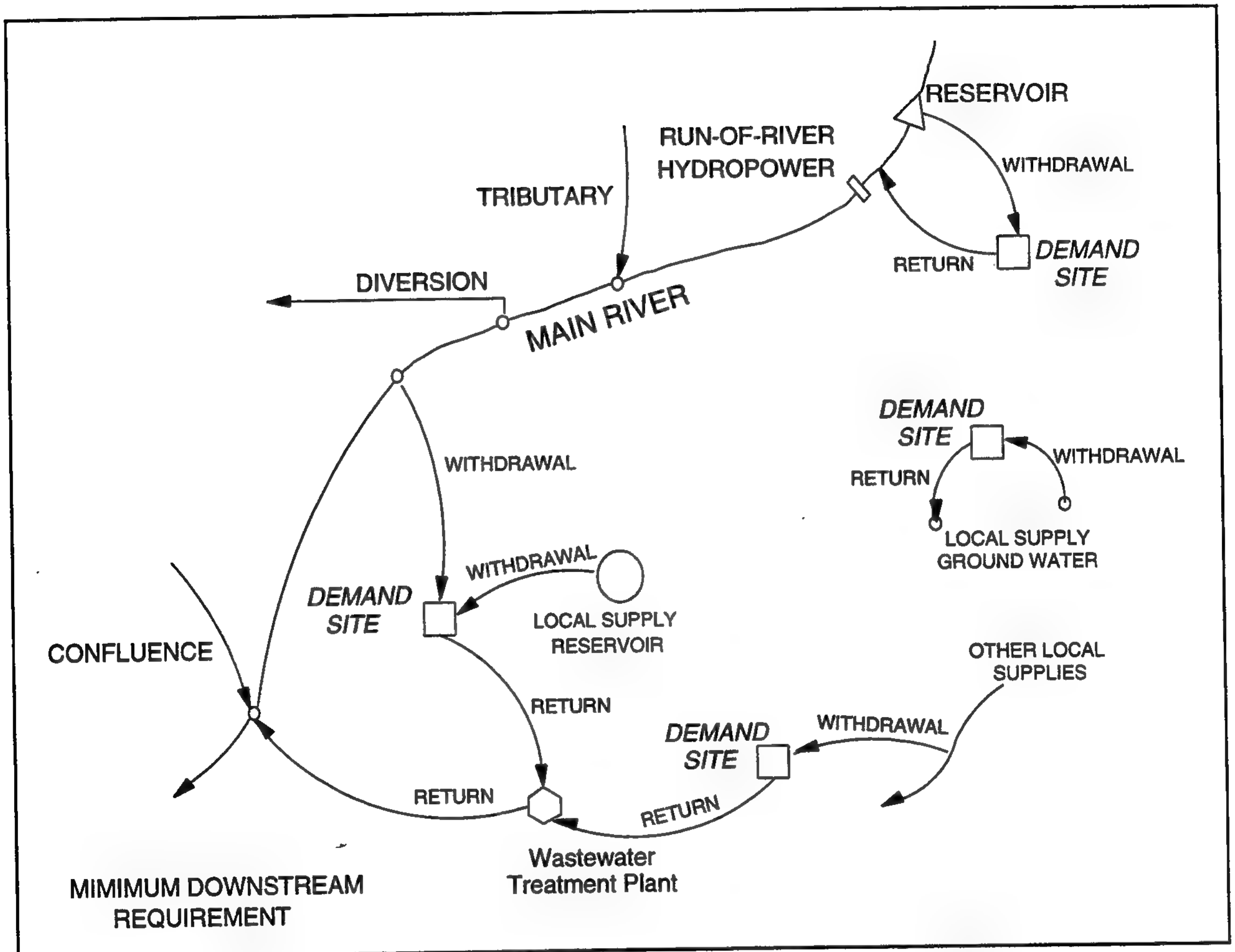


Figure 7: Supply and Demand Features Modeled by WEAP

Demand Sites. Demand sites are best defined as representing sets of distribution systems that may share an actual physical distribution system, that are all within a defined area, or that may share an important withdrawal supply point. Possible options for defining distribution systems are: major cities, counties, individual surface or groundwater withdrawal points managed by a single entity such as a industrial facility, an irrigation district or a unique water treatment plant. Decisions must be made about lumping demands together and/or separating out key water use sites in the system. Inventorying actual physical infrastructure, such as pumping stations, withdrawal facilities, treatment plants, well fields, etc... in a water system can be a helpful way to think about defining demand sites. Categories of demand sites could be irrigation districts or agencies, individual self-supplied industrial sites, water treatment plants, water utilities, etc. The data used depends upon: the nature and form of the available data on demand, the detail desired for the analysis, the form used to report WEAP results, and upon the limitations of the rules used to manage and allocate water in WEAP. These limitations include the maximum number of possible demand sites, the limitation that only one river withdrawal point per demand site can be simulated in the river program and the order in which local supplies and river node withdrawals linked to a single demand site are used to fulfill demands. The features of a typical demand site are illustrated in Figure 8.

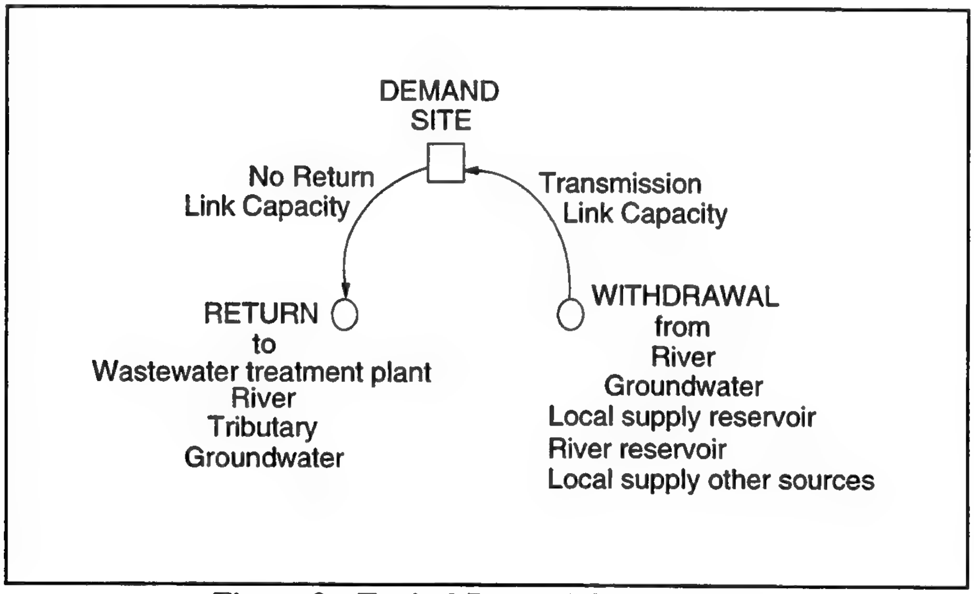


Figure 8: Typical Demand Site Features

At this point consideration should be given to thinking carefully about the configuration of the system of supplies and demands (i.e., identifying which supplies go to what demands), the detail of the accounting picture you wish to present, any key water uses, and any key supply sources and river points that need to be tracked, described and evaluated.

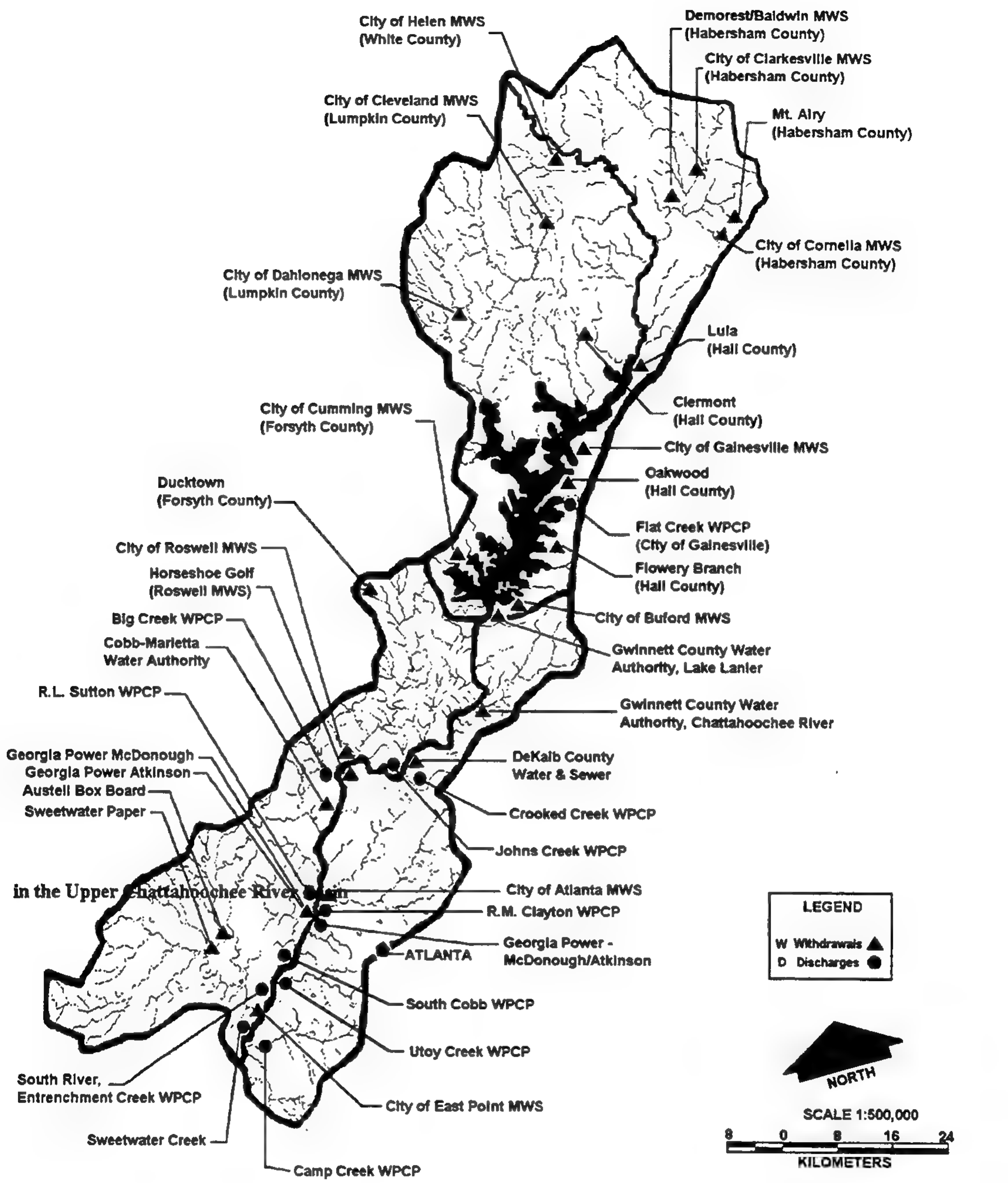
Twelve of the 16 counties falling within the upper Chattahoochee study area have been treated as separate demand sites (Table 2). While these sites lump industrial, municipal, domestic and agricultural water demands into a single demand site, this choice is intended to indicate the overall demand and supply condition for each county in any WEAP analysis.* Reporting by

counties recognizes the individual concerns of participating political entities in the study process. The four counties that do not appear as demand sites are nevertheless included in the demand branch structure as destinations of water transfers. WEAP's limitation of just one river withdrawal point per demand site also necessitates the creation of additional demand sites in those counties withdrawing significant quantities of water from more than one point on the river (i.e. Gwinnett and Fulton Counties each have more than one withdrawal point on the Chattahoochee River).

In addition to the counties there are other large water using entities that are politically and economically important in the study area. Examples include the public water supply systems serving the Atlanta Metropolitan Area, and the private water withdrawal systems for the thermoelectric power plants. The principal wastewater treatment facilities and water supply intakes are shown in Figure 9. These non-county entities need to be explicitly reported on as well. Twelve more demand sites have been defined for the study area to accommodate the need to report on specific significant subsets of water use in several of the counties, and to keep track of key river withdrawal points. In Table 3, the special demand sites are listed along with the subset of county demands served. In counties with special demand sites (from Table 3), the balance of demands are attached to the county demand site. Thus, some counties are represented by more than one demand site.

Wastewater Treatment Facilities. Wastewater treatment plants receive water from specified demand sites and then return water to specified river nodes or groundwater sources. Water can be received from any number of demand sites but can only return water to a single river node and/or a single groundwater source. Wastewater outflow is specified as either a percentage of inflow or as an absolute value.

For the upper Chattahoochee study, an early version of the WEAP model was developed with return flow from demand sites directly to river nodes. Later, when the capability to model wastewater treatment facilities was added to the program, it was decided not to change the original configuration because the simulation would not change. In other cases, however, modeling wastewater treatment facilities may be advantageous and even necessary to configure an accurate representation of the water system. A detailed discussion of the wastewater return flows is included in Appendix A.



NOTE: Some demand sites have no specific withdrawal points (ex. Dawson County) and therefore do not appear on the map.

Figure 9: Principal Wastewater Treatment Facilities and Water Supply Intakes in the Upper Chattahoochee River Basin

Table 3
Special Non-County Based Demand Sites for the Upper Chattahoochee River Study

Demand Site	City & County	Demand Set
Gainesville Municipal Water Supply (MWS)	Gainesville, Hall Co.	All industrial, municipal and commercial water uses in Gainesville.
Buford Municipal Water System (MWS)	Buford, Gwinnett Co.	All industrial, municipal and water uses in Buford
Gwinnett Water & Sewage Authority, Lake Lanier withdrawal point (W&S Lake)	Lawrenceville & AMA[1] in Gwinnett and Rockdale Counties	The share of industrial, municipal, and commercial water uses in this area served by the Lake Lanier withdrawal.
Gwinnett Water & Sewage Authority, Chattahoochee River withdrawal point (W&S Chat)	Lawrenceville & AMA in Gwinnett Co.	The share of same demand as above served by the withdrawal point below Buford Dam (went off line in 1993).
Atlanta/Fulton County-Chattahoochee River	AMA in Fulton Co.	M/C/I demand in Fulton Co.
Dekalb Water & Sewage Authority (W&S A)	AMA in DeKalb, Rockdale and Henry Counties	All industrial, municipal and commercial water uses it the area served by this water system.
Roswell Area Supply	Roswell, Fulton Co.	The city of Roswell M/C/I water use and Horseshoe Bend Properties commercial use.
Atlanta Municipal Water Supply (MWS)	AMA in Fulton, Clayton and Fayette Counties	All AMA M/C/I use in Fulton except for the Roswell area and M/C/I demand connected to this system in several other counties.
Georgia Power	Atlanta, Cobb Co.	The thermoelectric cooling for the McDonough and Atkinson Plants.
Cobb County-Chattahoochee Marietta Water Authority	AMA in Cobb and Douglas Counties	M/C/I in AMA in these counties served by Chattahoochee River withdrawal; transfer to Douglas Co.
Cobb County-Lake Allatoona Marietta Water Authority transfer	AMA in Cobb and Paulding Counties	M/C/I in AMA in Cobb served by Lake Allatoona withdrawal; to Paulding County.
East Point Municipal Water Supply (MWS)	AMA in Douglas Co.	All M/C/I in AMA in Douglas served by this withdrawal.

[1] AMA refers to the Atlanta Metropolitan Area, and includes portions of 9 counties, 5 of which fall partially within the Chattahoochee watershed area.

Note: All these distribution systems get their water supplies only from precise water withdrawal points, permitted to the agency operating the distribution system. (See Georgia Department of Natural Resources, 1984, pp. 24-26)

Local Supplies - Surface Water. Local Supplies cover three types of supply resources: 1) groundwater supplies, 2) local reservoirs, with predetermined monthly water quantities that can be stored but are managed independently of any river system, 3) local 'other-type' sources, also with predetermined water quantities available on a monthly basis but with no storage capability (Figure 10).

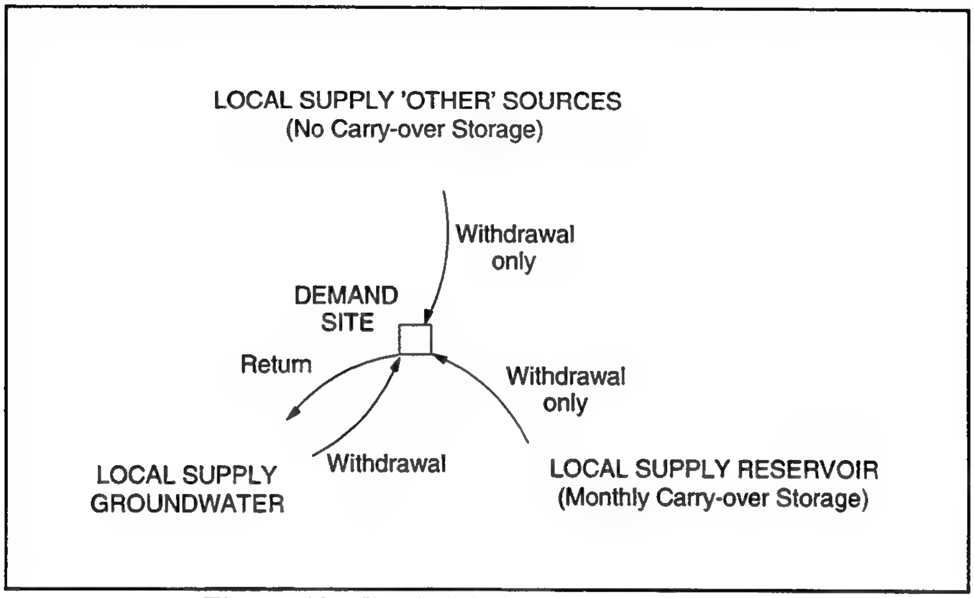


Figure 10: Typical Local Supply Features

Above Lake Sidney Lanier all water withdrawals on portions of creeks flowing into the mainstem are treated in the SUPPLY program as coming from local 'other-type' supplies. The streamflows at these locations become the available local supply. It was convenient and possible to do this because these withdrawal activities are small (much less than 3785 cmd (1 mgd) or .044 m^3/s (1.55 cfs) compared to the big withdrawals (up to 1.17 million cmd (310 mgd)) that occur on the Chattahoochee River, and therefore have insignificant impact on the balance of the river resources. An advantage of this approach is that creeks having upstream withdrawal activities can be represented as simple confluence inflows in the River component, rather than as tributaries requiring their own set of withdrawal nodes. The streamflow record at each creek-based permitted withdrawal point becomes a local 'other-type' supply in the study area. It also becomes a confluence inflow to the River. By separately modeling these two aspects of creeks, a simpler model of the Chattahoochee River can be used in the WEAP River simulation.

Six unique Local Supply sources are identified in the Chattahoochee study configuration, each one referenced to a surface water withdrawal permit at a creek in the study area. The creek mile locations for the permits are used to identify the withdrawal points and have been taken from a list of permitted withdrawals (Georgia Department of Natural Resources, 1984, pp. 24-26).

Local Supplies - Groundwater. As a local supply source, groundwater inflow, outflow and storage are simulated as illustrated in Figure 11. Initial and maximum accessible storage volumes are specified which represents water that is accessible for withdrawal by pumping. Return flow from demand sites and wastewater treatment plants and seeepage (gain) from the main river are

sources of inflow to the aquifer. If desired, these inflows may be lagged one or several years to simulate slow infiltration to the aquifer. An annual natural recharge may also be specified.

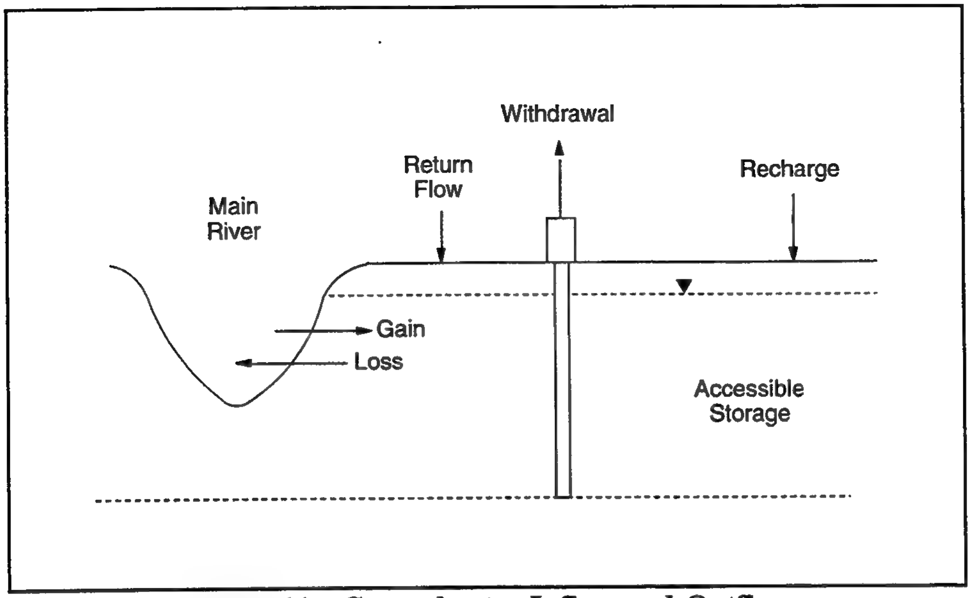


Figure 11: Groundwater Inflow and Outflow

Only one groundwater supply is used to represent groundwater withdrawals from the Blue Ridge/Piedmont aquifer system which underlies all of the study area (USGS, 1990). Groundwater use in the study area is limited so it did not appear warranted to breakdown the distribution of groundwater activity by any smaller aquifer units. In other cases where groundwater pumping is significant, it may be important to associate withdrawals with different aquifer subunits, either vertically stratified or horizontally distributed.

Local Supplies - Local Storage Reservoirs. No local storage reservoirs were identified in the study area.

Local Supplies - Unaccounted Surface Water. Another local 'other-type' supply source, called "Surface Water - Unaccounted", has been included in the Local Supplies category for this study. This supply source is a user-defined accounting category that serves several purposes in the upper Chattahoochee study. First, it functions as a source for numerous unpermitted withdrawals that occur throughout the study area and are not identified with a supply source. For example, in the DEMAND program the rural and agricultural demands by county have been included, based on estimates by the Georgia Department of Natural Resources (1984); however the individual withdrawal points and sources of water are not identified because permits are not issued for these categories of withdrawals. Considered individually, the unpermitted withdrawals may seem inconsequential, but as a whole they can constitute a significant percentage of a county's demand. For this reason the unpermitted category of withdrawal has been included as a demand for each county in the basin. The unaccounted surface water source is assigned a very high link capacity allowing it to meet and thereby quantify these demands in the output tables.

A second function of the unaccounted surface source is to quantify deficits from sources with a higher priority. The unaccounted category creates a source with unlimited capacity and a lower priority than all sources connected to a demand site to provide the deficit information directly. The unaccounted surface water source fills this role in the upper Chattahoochee study. An alternative approach is to simply use the 'Unmet Supply Requirement' report created for each demand site in the WEAP program.

A deficit can arise from two different circumstances, the first being that a higher priority source has insufficient water available to meet demand. The second occurs when a higher priority source has sufficient water, but the link capacity (representing the permit level) limits the amount of water that can be withdrawn. When these circumstances occur the amount of water transmitted from the unaccounted surface water source serves to quantify the unmet demand, which may correspond to the necessary increase in link capacity or the inadequacy of the higher priority source(s). The quantity of water withdrawn from the lower priority unaccounted surface water source can be compared against the unused water remaining in the higher priority source to determine the cause of the deficit. This comparison also indicates if and how much the link capacity can or should be increased.

In addition to the unpermitted withdrawals, many of the demand sites representing counties include municipalities for which permit and demand information is available. This type of demand is incorporated in the county demand site as well, and the link to the permitted source is established with a capacity equal to the permit level. The objective of defining counties with several components of demand and different sources as single demand sites is to paint a picture of the areal distribution of demand by county. When the unaccounted surface water source is added in to serve the dual purposes of meeting unpermitted demand and quantifying deficits from higher priority sources, separating how much of the unaccounted surface water is being used for each purpose becomes difficult; information on the adequacy of link capacities and individual sources is sacrificed to obtain the picture of demand by county.

Splitting each county into two demand sites, each with an unaccounted surface water source, is an alternative method of defining the demand site. By using two demand sites to represent each county, the county-wide demand is still readily apparent as well as additional information on individual sources and demands within the county. One demand site would include all demands that are met by permitted withdrawals, and would be connected to the specific sources with link capacities equal to the permit levels. The unaccounted surface water source would also be connected and assigned the lowest priority, providing information on the amount and cause of supply deficits. The second demand site would take in all estimated but unpermitted demand, and draw only on the unaccounted surface water source. This demand site would quantify the present and future amount of water use that occurs but is largely unmonitored.

Quantitatively the unaccounted surface source is defined as an arbitrarily large amount of water such that the demand will always be met. The amount shown on the Annual Resources table is not physically based. Because unaccounted surface water does not represent an actual supply source, it is not included in the total of in-basin water supply resources. Again, an alternative option is not to create an unaccounted surface source and simply use the information in the 'Unmet Supply Requirement' report.

Modeling the River. The River component covers those water resources whose allocations will be simulated in the River option of the SUPPLY program (Figure 12). At the same time non-consumptive water uses competing for these river resources can be tracked in the River model as user-specified requirements for instream flows, reservoir storage levels, and hydropower demands. The River model is created from a set of user-defined river nodes starting from the upstream point of a system. Tributaries have all the same features as rivers (they are identical) and can be used as separate rivers simply by not linking them into the main river.

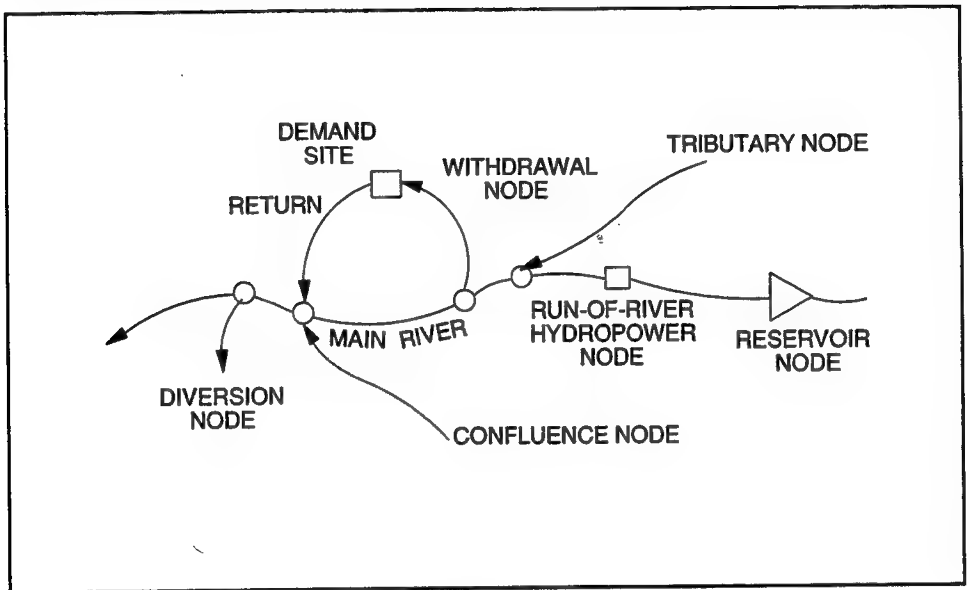


Figure 12: Typical River Features

The River calculations use the concept of a 'group' of nodes to make storage and flow decisions on different parts of a river or a tributary (Figure 13). A group of nodes starts at a reservoir and includes all nodes down to the next reservoir. The first group in any river will start from the headwater, if the highest river node is not a reservoir. The last group ends at the last node on the river. On tributaries the last group ends at the last node for the tributary, which may or may not join with a tributary node on the main river.

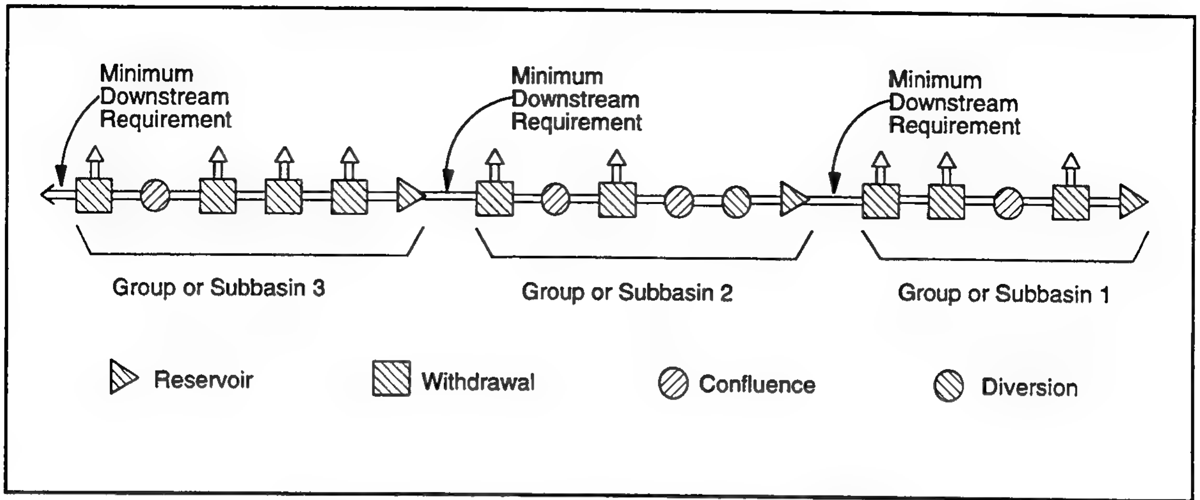


Figure 13: Grouping Nodes into Subbasins

The U. S. Geological Survey's stream gages in the Upper Chattahoochee basin are shown in Figure 14. They provided the data necessary to do the River simulation and to calculate ungaged runoff at locations where there were no gages. Only the portion of the Chattahoochee River from Lake Sidney Lanier down to the Fairburn Gage has been included in the River simulation. This decision was influenced by the fact that monthly historical inflow data into Lake Sidney Lanier was readily available from the Mobile District and there was less data available for runoff at points above the Lake. And with all the major river withdrawal and discharge points located on or very close to the main stem between these two locations, it was possible to simplify the River simulation to include only those activities and actions occurring close to this portion of the river. Also, as discussed under Local Water Supplies, water use activities above Lake Lanier are not large enough to have a significant impact on the river system. If in the future, any of these withdrawal sites became significant, their impacts on the river resources could be incorporated into the WEAP analysis by extending the current River model to include nodes in the headwaters area.

The gaged surface water sources in the upper Chattahoochee watershed are shown in Figure 15. In addition there are ungaged sources which are represented at "local" confluence nodes. All consumptive use activities on creeks are modeled in the SUPPLY program as local supplies. There are four gaged creeks (Suwanee, Big, Sope, Peachtree) between Lake Sidney Lanier and Fairburn gage and one tributary, Sweetwater Creek. The monthly streamflow data for each of these gages (January 1980 to December 1989) serve as the natural water inflows into the main river, in addition to the inflow into Lake Lanier, and are modeled as simple confluence nodes in the River component except for Sweetwater Creek which is modeled as a tributary.

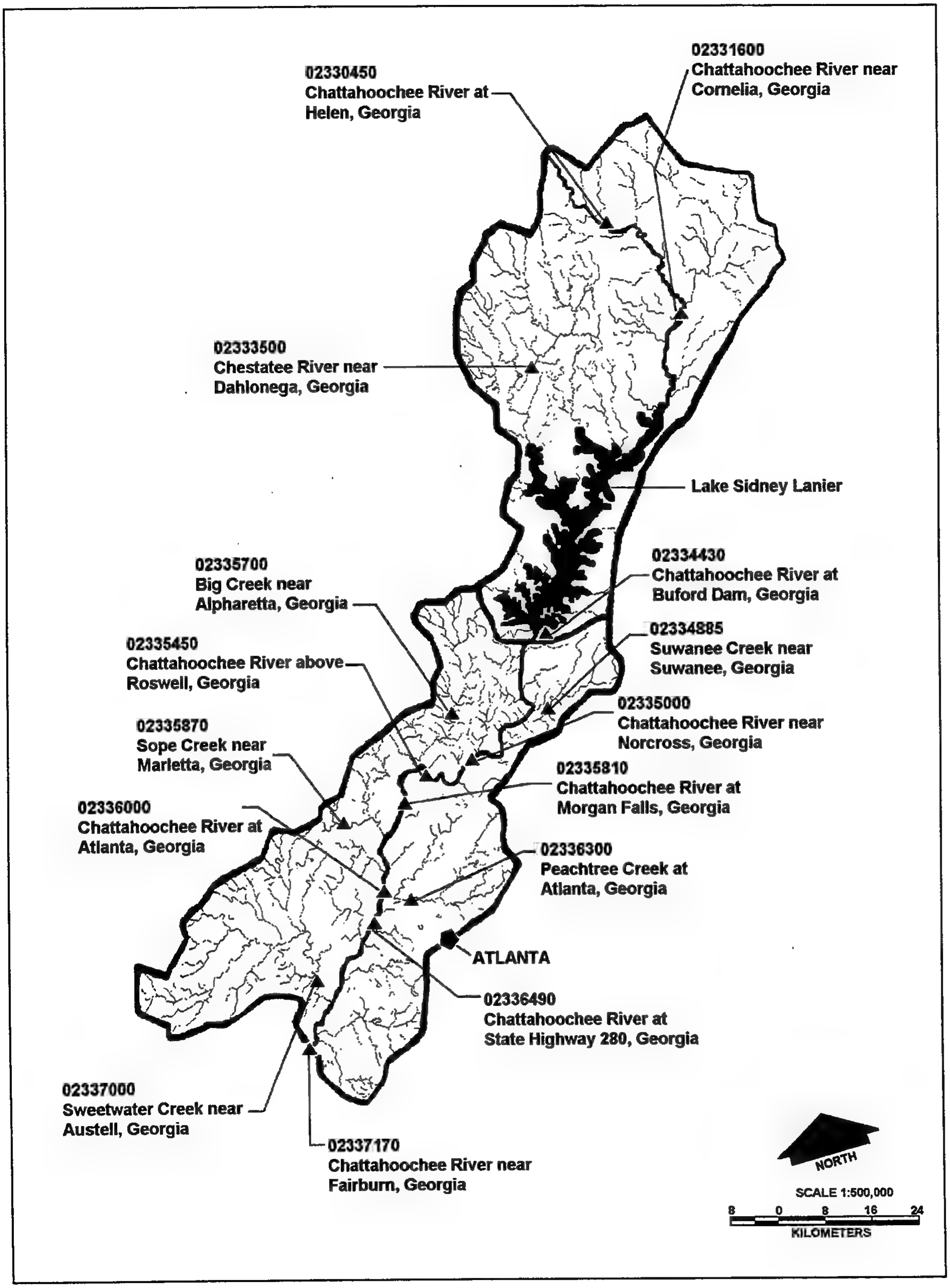


Figure 14: U.S. Geological Survey Stream Gages in the Upper Chattahoochee River Basin

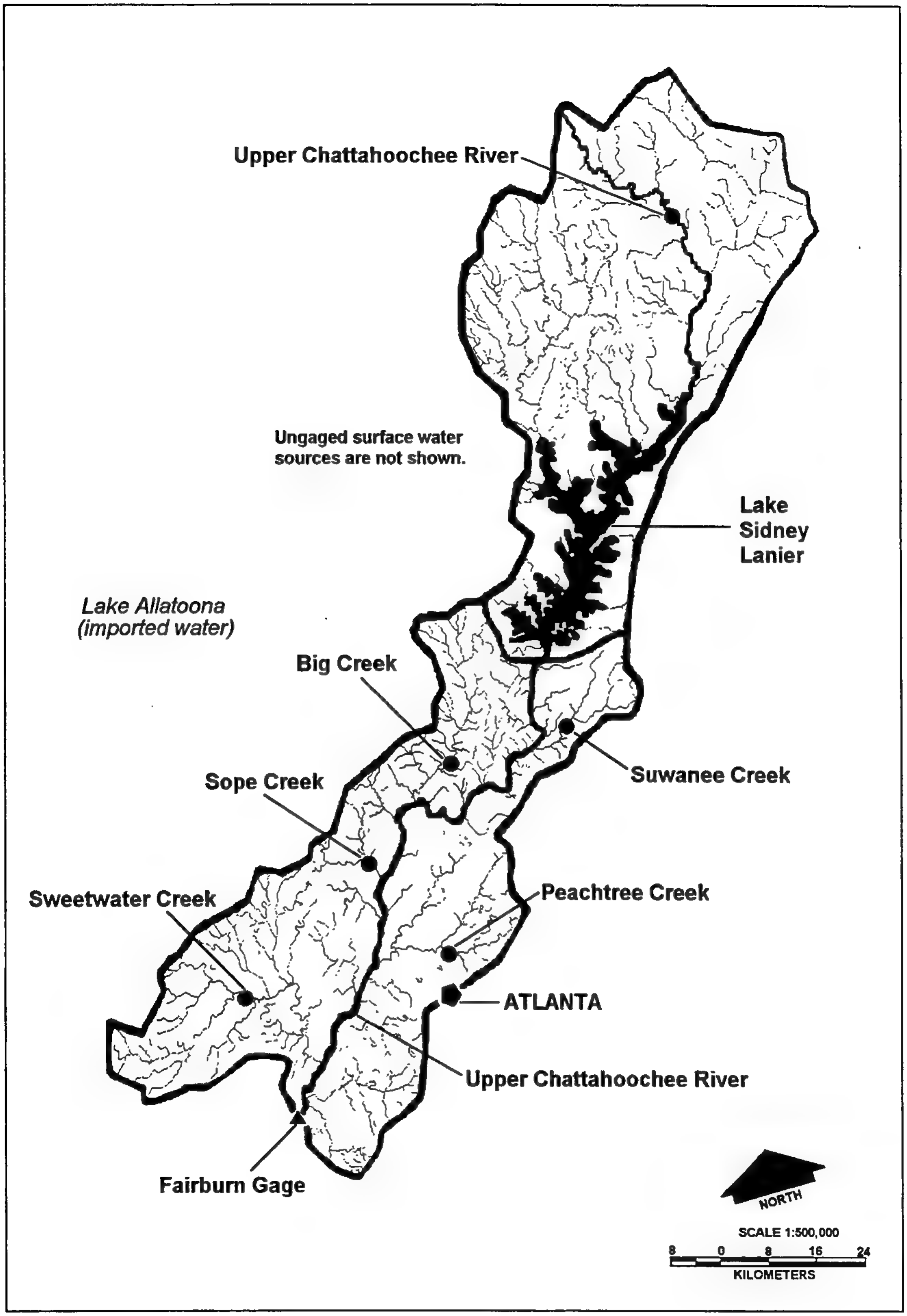


Figure 15: Gaged Surface Water Sources - Upper Chattahoochee River Basin

Runoff from ungaged areas to the Chattahoochee River must be accounted for and "local" confluence flow nodes are used to input these streamflow values. Six such local confluence nodes are used, each one reflects ungaged streamflow between a set of two river gages. For example, LOCAL 280 is the confluence node for runoff from the ungaged watershed area between the Atlanta gage and the Route 280 gage on the Chattahoochee River. Likewise, LOCAL FAIRBURN is the confluence node for the ungaged runoff contribution between the Route 280 gage and the Fairburn gage. How historical flow data was estimated for these ungaged 'local' contributing areas is explained in more detail in Appendix B - Developing Supply Data.

Major components of the River simulation include: 25 reaches (a reach is the section of river between any two nodes), four critical points with instream flow requirements, seven major withdrawal nodes, one key storage reservoir (Lake Sidney Lanier), two main hydropower plants (Buford Dam and Morgan Falls Dam), and eleven confluence inflow points. The use of many confluence points is mainly for ease in making any desired changes to the estimates of historical ungaged runoff flows. They also serve to spatially distribute these ungaged contributions to the river flow at different points.

Linking Demand Sites and Local Supply Source. The system network is created by linking all the components that have thus far been defined in the system. If the tasks described above have been successfully completed, this step follows easily from the work and effort involved in defining the system's components. Each demand site is explicitly linked to local supply(ies) and to any one river withdrawal node in your system configuration. For each demand site WEAP limits the selection to a maximum of 10 different local supplies plus one river node, plus one tributary node.

In the upper Chattahoochee watershed, all of the county demand sites are linked to the one defined groundwater supply and to the unaccounted surface water 'other' supply. Water transmitted along these two links to a demand site represents the non-permitted (i.e., less that 378 cmd (0.1 mgd)) withdrawals from the groundwater aquifer and from unknown surface water points. In a few cases, the groundwater link also includes any permitted withdrawals. The agricultural and rural domestic sectors make up the vast majority of the ground and surface water non-permitted withdrawals. Access to groundwater for each county demand site is limited or controlled in the model through a transmission capacity limit on the link between the demand site and the groundwater source. Because the surface water unaccounted supply serves as an accounting category for all unmet demands, transmission capacities for links to this source as well as its availability are not physically or legally based, and are set to arbitrarily high numbers.

Some county demand sites in the study area are also linked to one of the specific other-type supply points, each reflecting a permitted surface water withdrawal. For example, Habersham County is linked to two specific 'other-type' supplies, to the groundwater supply, and to unaccounted surface water. The link to Soque River mile 10.5 is the permitted supply serving Clarksville City, via its municipal system. Camp Creek mile 3.5 serves the city of Cornelia, and also is covered by a withdrawal permit. The city of Demorset in Habersham county is permitted to withdraw groundwater. This withdrawal is included in the groundwater link along with any non-permitted groundwater uses. No other specific supply points for Habersham County are known to exist. All remaining water use is from un-permitted surface water withdrawals. Estimates of non-permitted groundwater and surface water use for the parts of each county that lie inside the study area hydrologic boundaries made in the "Water Availability and Use,

Chattahoochee River" report (Georgia Department of Natural Resources, 1984) are used in this case study. Any permitted surface water withdrawal points serving entities in a county that are not part of one of the specialized distribution systems are covered by a separate link to the appropriate county.

The specialized demand sites are linked only to those water supply points for which they have permits. For example, the Atlanta MWS demand site is linked to the groundwater aquifer, and to the river withdrawal node 'Upstream Peachtree Creek'. The link to the groundwater reflects only the permitted groundwater withdrawal 1249 cmd (0.33 mgd) made by an industry (Anaconda Aluminum) in the demand area and is attached to this demand site. The link to the river withdrawal node is the permit held by the Atlanta MWS to withdraw up to .681 million cmd (180 mgd) of river water at this location.

Determining Water Allocation Priorities. At each demand site a priority of water withdrawal may be established for each river and local supply source. This is accomplished through the use of three priority systems. First, a priority is established between withdrawal from the main river or local supplies. Second, for local supplies a priority is established between the various local supply sources e.g., creek, local reservoir, groundwater. Third, for river supplies a priority is established between the river withdrawal nodes. These priorities are illustrated in Figure 16 and 17. Figure 16 shows Local Supplies being first priority and the Main River second. Of the local supplies creek A is the first priority and so on. Figure 17 illustrates the priorities between competing demand sites along the Main River.

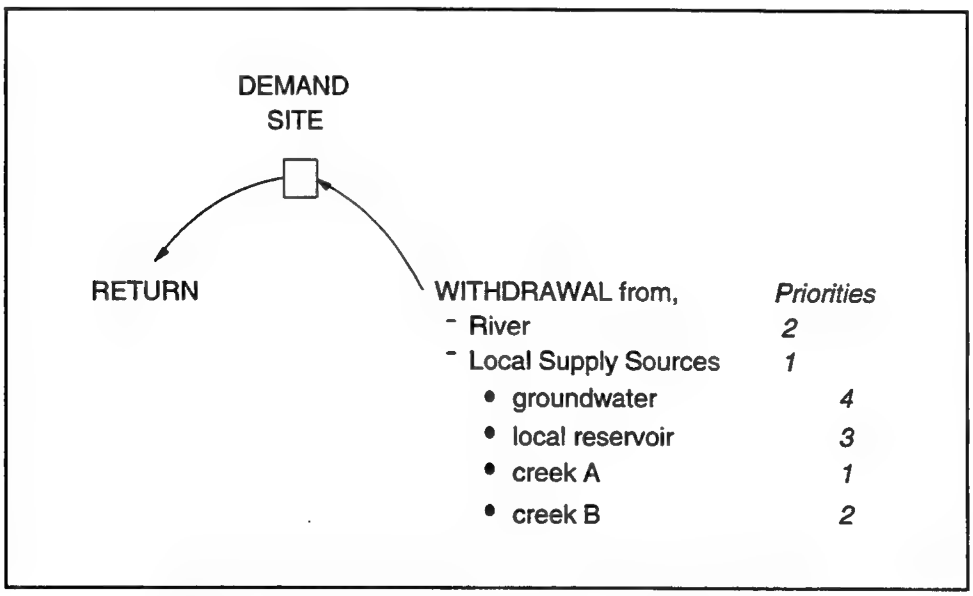


Figure 16: Priority Between Local Supply Sources

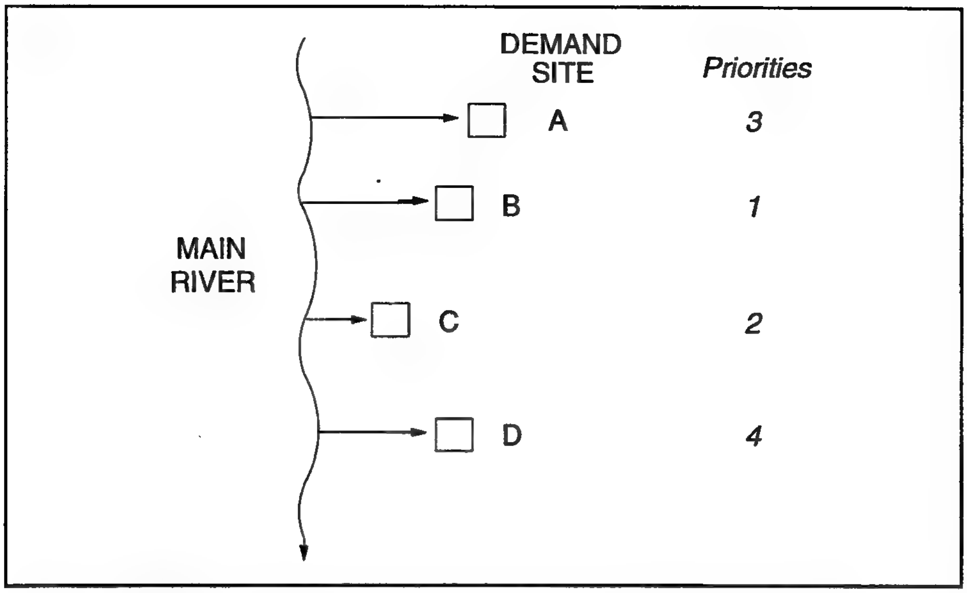


Figure 17: Priority Between Competing Demand Site along the Main River

In the upper Chattahoochee study, the priority between the river nodes and local supplies is established at each individual demand site. All but one demand site (Gainesville MWS which withdraws from Lake Lanier, a river node) takes water first from a local supply source. The priorities between local supply sources are established for each demand site. All river nodes are equal priority (priority = 1) so they share shortages equally.

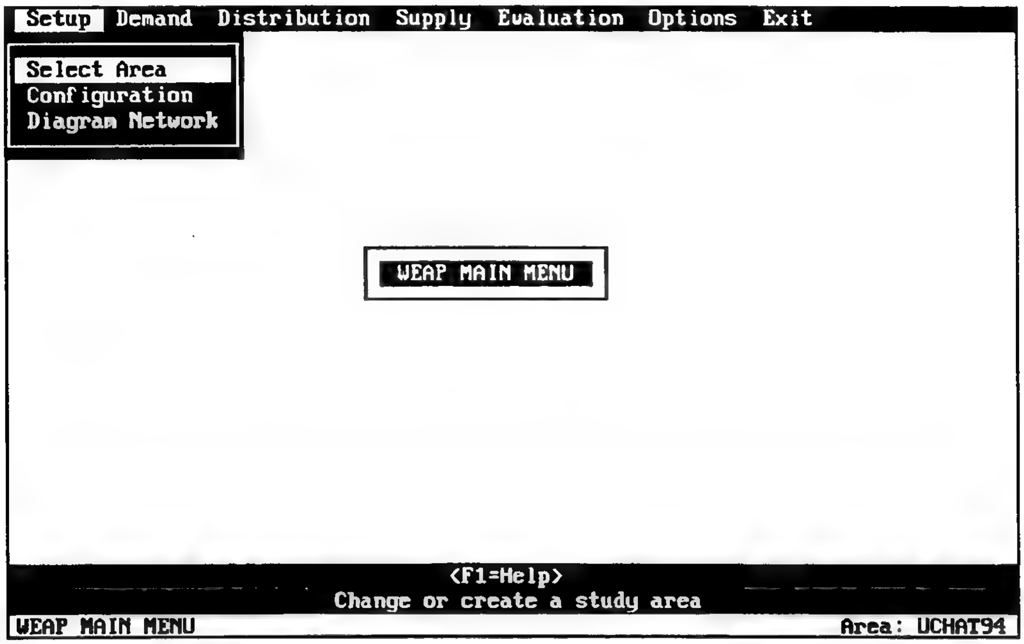
Under local supplies, the 'other-type' supply called 'SW-Unaccounted' is used to provide any remaining demand after all other available local supplies linked to a distribution system have been exhausted. Therefore, in all county demand sites the lowest priority (highest number) is assigned to this supply link. In effect it reflects levels of unaccounted surface water usage. Take the example of Habersham County: priority one is given to the Soque River 10.5 supply, priority two to the Camp Creek 3.5 supply, priority three to the groundwater supply, and finally the lowest priority to the unaccounted for surface water supply. Thus in serving the total water needs of Habersham County, first the Soque River will be allocated. Two factors serve to limit what can be taken from any one supply. The first is the availability, and the second is the transmission capacity on the link between the supply source and the demand site. All demand sites linked to a given supply and holding the same priority number will equally share the available resource up to their individual link capacities.

<u>The Network Diagrams.</u> In the SETUP program diagrams of the system configuration can be generated once the components have been created and linked. This feature is used to evaluate and check the representation of the study area against the user's conception of it. Modifications to the system can be made, and a new diagram generated. It is desirable not to move on to the other program modules until you are reasonably satisfied with the configuration of the system. WEAP does not prevent you from working with other program modules before you are finished with the configuration. At a minimum, however, you must create some demand sites before you

can start the DEMAND program. Likewise for SUPPLY, you must first create some local supply components or define river nodes, before you can activate this program.

'SETUP' Menu

The capabilities and data requirements for the SETUP program are shown in the menu screens which follow. The main SETUP Menu is shown below.



Select Area. UCHAT94 is selected as the study area for WEAP analysis. The user may select any previously developed area or create a new area. The option Select Area refers not only to the geographic region covered but more importantly to the database containing the WEAP data.

Configuration. The Configuration option describes the basic structure of the components of the study area including:

```
C O N F I G U R A T I O N   D A T A   M E N U

General Data
Hydrologic Fluctuations
Demand Sites
River Names
Main River Nodes
Tributary Nodes
Local Supply Sources
Wastewater Treatment Plants
Supply Priorities and Transmission Links
Demand Site Return Links
Wastewater Treatment Plant Outflow Links
River Supply Priorities
Monetary/Cost Parameters

View Data Echo

X) Exit

<F1=Help>
Enter area name, years, units, historical data and river simulation switches
SETUP                                                          Area: UCHAT94
```

General Data. The general data for the upper Chattahoochee study is shown in the General Data Menu. Demand data are entered for up to five years and results can be reported for up to five years. Note that the reporting years are within the data years. Historical streamflow data are entered for supply and the river accounting will be simulated.

General Data

Page 1 of 1

Area Name For Reports	U. Chattahoochee				
Demand Data Years	1990	1995	1999	0	0
Default Reporting Years	1990	1995	1999	0	0
Demand water volume unit	CUB. METERS				
Distribution & Supply unit set	METRIC				
Use Historical Data?	Y				
Simulate River?	Y				

<F1=Help> <F10=Menu>

SETUP Area: UCHAT94M

Hydrologic Fluctuations. Because historical data are being used for streamflow, hydrologic fluctuations are not entered. Typical hydrologic fluctuation menus (not used in this study) are illustrated in the two Hydrological Fluctuations Menus.

Hydrological Fluctuations: Monthly Fluctuation Coefficients
(as fractions compared to normal year values) Page 1 of 2

	Very Wet	Wet	Dry	Very Dry
Jan	1.00	1.00	1.00	1.00
Feb	1.00	1.00	1.00	1.00
Mar	1.00	1.00	1.00	1.00
Apr	1.00	1.00	1.00	1.00
May	1.20	1.10	0.90	0.60
Jun	1.50	1.20	0.60	0.50
Jul	2.00	1.50	0.40	0.30
Aug	1.50	1.20	0.60	0.50
Sep	1.20	1.10	0.90	0.60
Oct	1.00	1.00	1.00	1.00
Nov	1.00	1.00	1.00	1.00
Dec	1.00	1.00	1.00	1.00

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SETUP Area: SAMPLE

Hydrological Fluctuations: Assumptions for Future Years
Page 2 of 2

Year	Type
1990	Normal
1991	Very Wet
1992	Wet
1993	Dry
1994	Very Dry
1995	Normal
1996	Wet
1997	Normal
1998	Normal
1999	Dry
2000	Dry

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SETUP Area: SAMPLE

Demand Sites. The demand sites for the upper Chattahoochee study area are identified in the two Demand Site Menus. They are identified by name and described by a note.

Demand Sites

Page 1 of 2

Demand Site	Note
HABERSHAM	GA county in HU#1
WHITE	GA county in HU#1
HALL	GA county in HU#1
GAINESVILLE MWS	City system, Hall Co.
LUMPKIN	GA county in HU#1
DAWSON	GA county in HU#1
FORSYTH	GA county in HU#1 & 2
BUFORD MWS	City in Gwinnett Co. w/ L.Lanier withdrawal
GWINNETT	GA county in HU#2 except for AMA
GWINET W&S LAKE	Lake Lanier Plant for Lawrenceville, and AMA
GWINNETT CHAT.	Chatahoochee plant for AMA in Gwinnet Co.
ATL/FULTON MWS	Treatment Plant for AMA in Fulton Co.
DEKALB	GA county in HU#2 except for AMA
DEKALB CO W&S A	Decatur and AMA

<F2=Options>

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>

SETUP Area: UCHAT94

Demand Sites

Page 2 of 2

Demand Site	Note
FULTON	GA county in HU#2 except for AMA
ROSWELL MWS	City supply, Fulton Co.
COBB ALLATOONA	System serving Marietta, Smyrna and AMA
COBB CHAT.	System serving Marietta, Smyrna and AMA
ATLANTA MWS	City system, including parts of Claytn &Rckdl
GEORGIA POWER	Thermoelectic Industry
COBB	GA county in HU#2 except for AMA
DOUGLAS	GA county in HU#2 except for AMA
EAST PT MWS	Douglas Co. serving East Point, AMA
PAULDING	GA county in HU#2

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>

SETUP Area: UCHAT94

River Names. The Chattahoochee River is identified on the River Names Menu as the main river in the basin. While no major tributaries are identified as supply sources to the Chattahoochee several small creeks serve as local supply sources and these are identified under the Local Supply Sources of the SETUP menu.

River Names

Page 1 of 1

Main River	U.Chattahoochee
Tributaries	SWEETWATER CRK

NB: Press F2 to define tributaries

<F1=Help> <F2=Options> <F10=Menu>

SETUP Area: UCHAT94

Main River Nodes. The main river nodes are identified on the Main River Nodes Menus for the Chattahoochee. These include one reservoir, Buford Dam - Lake Sidney Lanier, one hydropower generation at Morgan Falls, and confluence and withdrawal points along the Chattahoochee River. To the extent possible, nodes were named for prominent local landmarks.

Main River Nodes
U.Chattahoochee

Page 1 of 2

River Node	Type	Active In Base Year?
LAKE LANIER	RESERVOIR	Y
US SUWANEE CRK	WITHDRAWAL	Y
SUWANEE CR	CONFLUENCE	Y
NORCROSS LOCAL	CONFLUENCE	Y
ROSWELL LOCAL	CONFLUENCE	Y
DS JOHN'S CREEK	WITHDRAWAL	Y
HOLCOMB BRDG RD	WITHDRAWAL	Y
BIG CR	CONFLUENCE	Y
ROSWELL RD BRDG	WITHDRAWAL	Y
WL.CK/BG.JN.WW	WITHDRAWAL	Y
MORGAN LOCAL	CONFLUENCE	Y
MORGAN FALLS	HYDROPOWER	Y
J'NSON FERRY RD	WITHDRAWAL	Y
SOPE CR	CONFLUENCE	Y

NB: Nodes must be entered according to their physical sequence.

<F2=Options>

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>

SETUP Area: UCHAT94

Main River Nodes
U.Chattahoochee
Page 2 of 2

River Node	Type	Active In Base Year?
ATLANTA LOCAL	CONFLUENCE	Y
US PEACHTREE CR	WITHDRAWAL	Y
PEACHTREE CR	CONFLUENCE	Y
MRTA BLVD/WW.RT	WITHDRAWAL	Y
280 LOCAL	CONFLUENCE	Y
J.JACKSON PKWY	WITHDRAWAL	Y
HWY 20/S.COB WW	WITHDRAWAL	Y
CB/DGLS C LN/WW	WITHDRAWAL	Y
SWEETWATER CR	TRIBUTARY	Y
CAMBELLTON 166	WITHDRAWAL	Y
SWEET/CAMP WW	WITHDRAWAL	Y
FAIRBURN LOCAL	CONFLUENCE	Y

NB: Nodes must be entered according to their physical sequence.
<F2=Options>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SETUP Area: UCHAT94

Tributary Nodes. Sweetwater Creek is designated as a tributary in this study with a withdrawal point at East Point Municipal Water System.

Tributary Nodes
SWEETWATER CRK
Page 1 of 1

SWEETWATER CRK connected to Main River node

SWEETWATER CR

Tributary Node	Type	Active In Base Year?
EAST POINT MWS	WITHDRAWAL	Y

NB: Nodes must be entered according to their physical sequence.
<F2=Options>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SETUP Area: UCHAT94

Local Supply Sources. The local supply sources are specified on the Local Supply Sources Menu. Five are rivers and creeks that serve the demand sites in the area and one imported source from Lake Allatoona Reservoir. There is also one groundwater source and one general surface water category. This latter category provides the opportunity to account for water not provided by the other supply sources. It can be used to measure deficits in supply during times of drought, quantify unpermitted withdrawals, or measure demand above current permitted withdrawals.

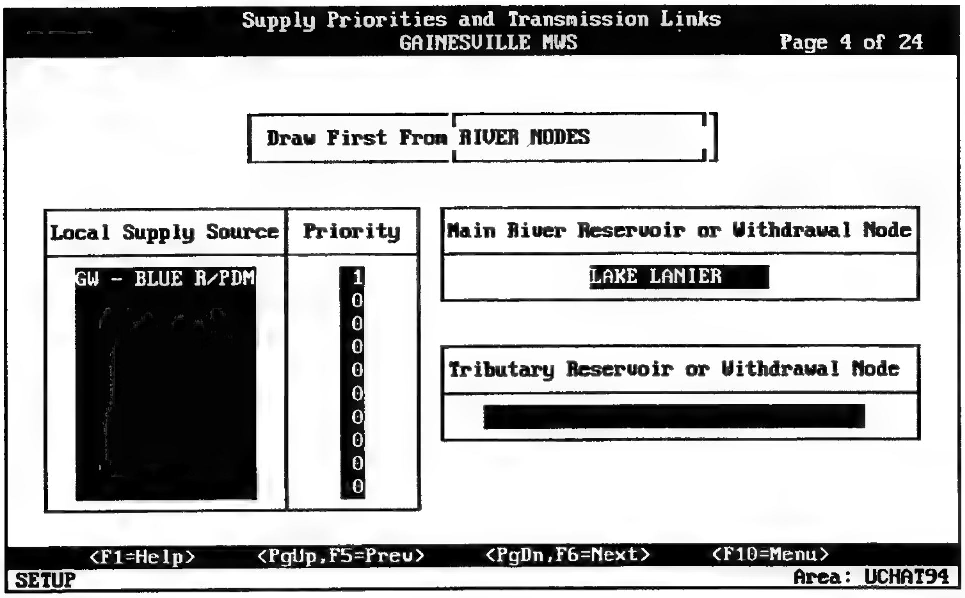
Local Supply Sources
(not on main river or tributaries) Page 1 of 1

Local Supply Source	Type	Active In Base Year?
Soque Riv 10.5	OTHER	Y
Turner Cr 0.5	OTHER	Y
Camp Cr 3.5	OTHER	Y
Yahoola Cr 5.0	OTHER	Y
Big Creek	OTHER	Y
Lake Allatoona	OTHER	Y
SW - UNACC'TED	OTHER	Y
GW - BLUE R/PDM	GROUNDWATER	Y

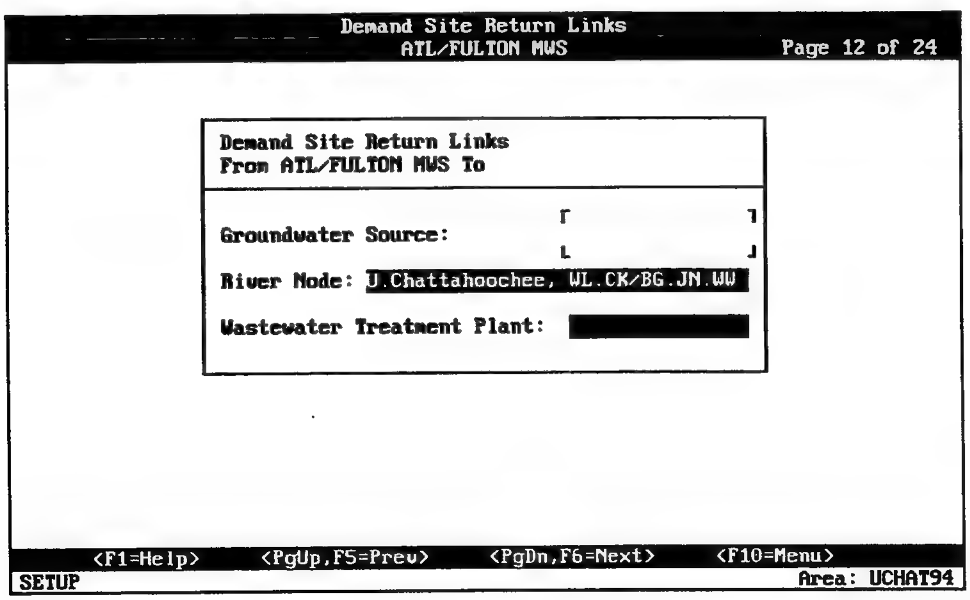
<F2=Options>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SETUP Area: UCHAT94

Wastewater Treatment Plants. No wastewater treatment facilities were included in the upper Chattahoochee study.

Supply Priorities and Transmission Links. The supply priorities and transmission links for Gainesville Municipal Water System is illustrated in the screen below. Water is first withdrawn from the river node which is Lake Lanier and then from the local supply source - groundwater.



Demand Site Return Links. Water may be returned from a demand site to a groundwater source, main river or wastewater treatment plan as illustrated in the data entry screen below.



Network Diagram. There are three network diagrams produced by WEAP. One shows each local supply source linked to the demand site it serves (Figure 18). The specific supply sources and their priority are shown for Habersham County in the System Network Menu below. The second network diagram is for the upper Chattahoochee River and shows all the facilities and interactions along the main river (Figure 19). All nodes for which data are provided in the SETUP program are identified in the river network diagram. The third diagram is for the tributary Sweetwater Creek (Figure 20).

Wastewater Treatment Plant Outflow Links. No outflow links were used in this study. All return flow was assumed to go directly from the demand site to the supply source.

River Supply Priorities. Priorities between demand sites withdrawing water from the main river or tributaries is specified using the river supply priorities data entry screen. For the upper Chattahoochee River all demand sites were given to the same priority.

River Supply Priorities

Page 1 of 1

Demand Site	River Supply Priority
GAINESVILLE MWS	
FORSYTH	1
BUFORD MWS	1
GWINET W&S LAKE	1
GWINNETT CHAT.	1
ATL/FULTON MWS	1
DEKALB CO W&S A	1
COBB ALLATOONA	1
COBB CHAT.	1
ATLANTA MWS	1
GEORGIA POWER	1
EAST PT MWS	1

NB: Only Demand Sites linked to main river or tributary nodes are displayed.

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>

SETUP Area: UCHAT94

Monetary Cost Parameters. Cost data was not used in the upper Chattahoochee study.

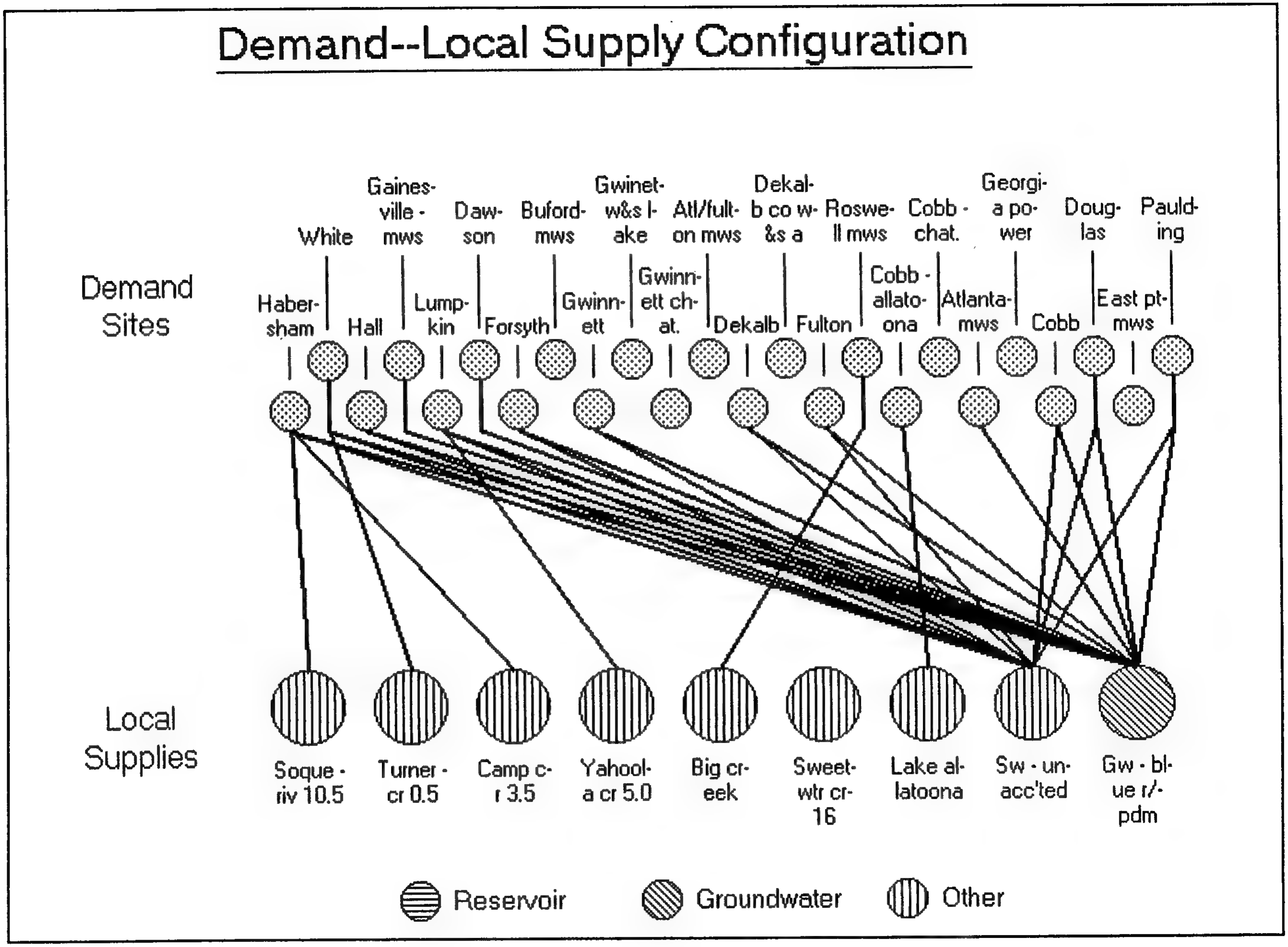


Figure 18: Demand-Local Supply Network Diagram

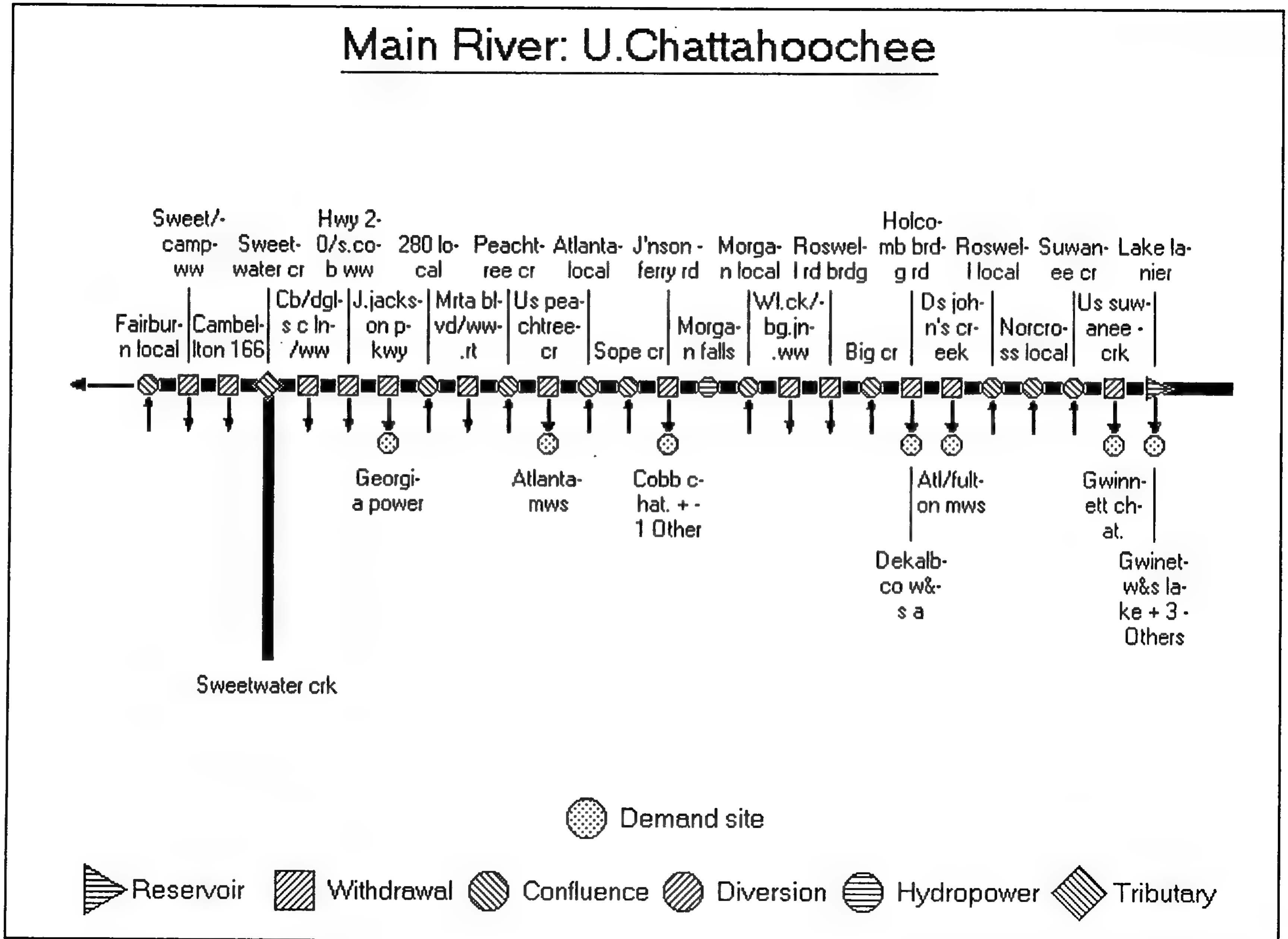


Figure 19: Main River: Upper Chattahoochee Network Diagram

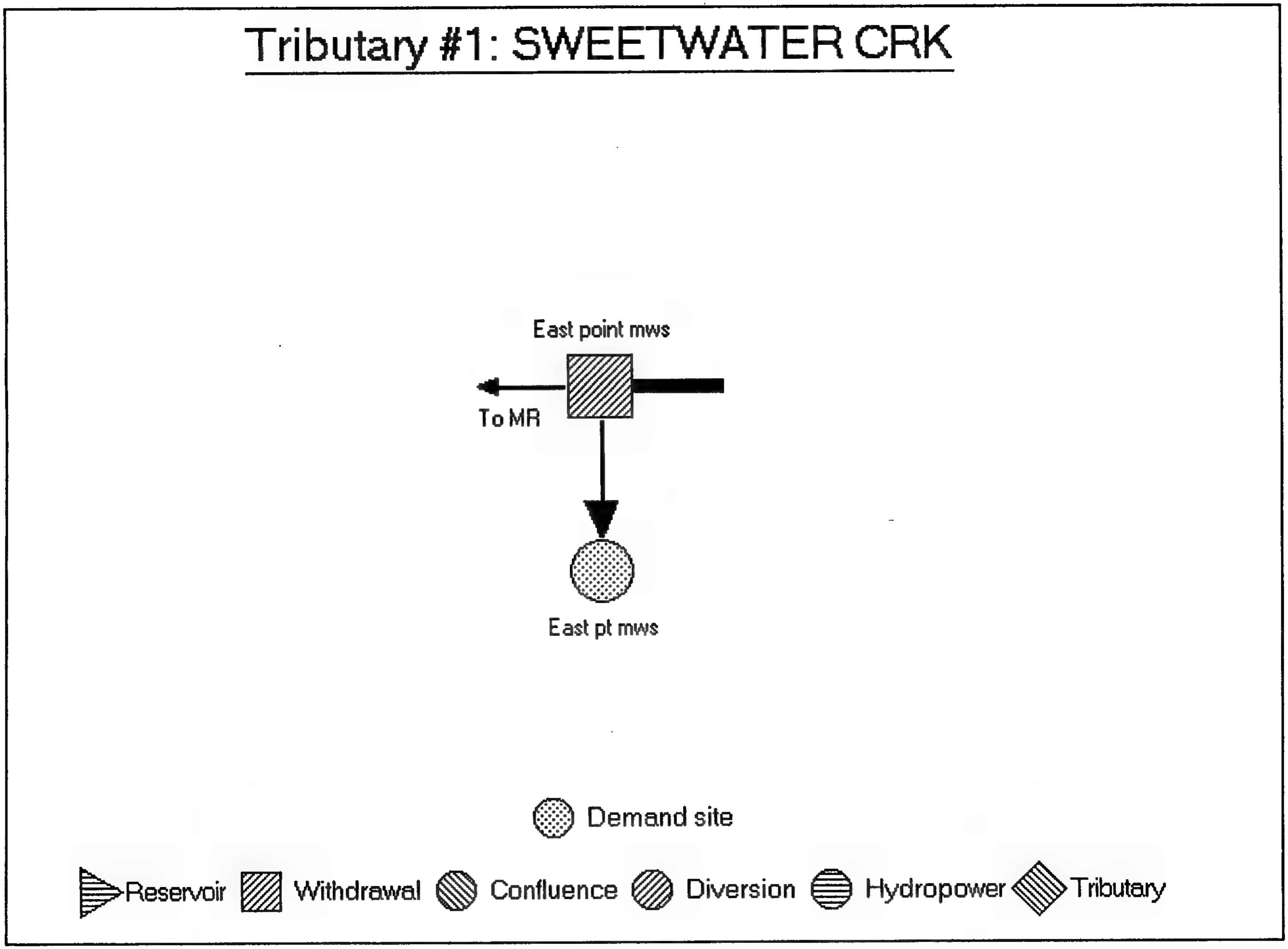


Figure 20: Sweetwater Creek Tributary Diagram

MOVING ON TO THE DEMAND PROGRAM

The DEMAND program data for the upper Chattahoochee study are based on several sources of water use data for the study area. These sources are described in Appendix A - Data Sources. Most 1990 water use information in this report is taken from plant production data provided by the Georgia Department of Natural Resources; some is given as a projection of final requirements for municipal, industrial and agricultural use aggregated to the city and/or county level. Data on water using driving variables such as population, industrial production units, or crop acreages, and the associated water use levels were not used in the study. The typical structure of the data entered into the DEMAND program contains four levels as illustrated in Figure 21. The demand data are connected to the demand site at the lowest, or water device, level.

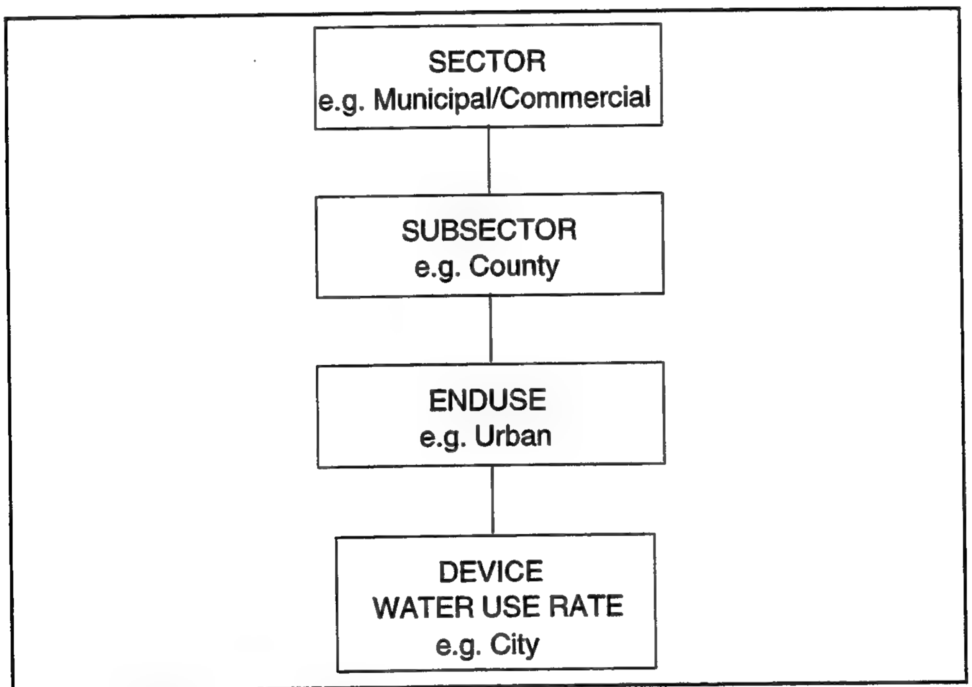


Figure 21: Typical Demand Data Branch Hierarchy

Defining the Demand Sectors, Subsectors, End-Uses and Devices

Examples of the demand branch tree for the upper Chattahoochee data are shown in Figures 22 and 23. The hierarchy for Habersham County in 1990 is illustrated in Figure 22. Figure 23 shows what in WEAP is called a Demand Echo report and illustrates the demand structure and data for all sectors. Appendix C - Demand Branch Data displays the complete data set.

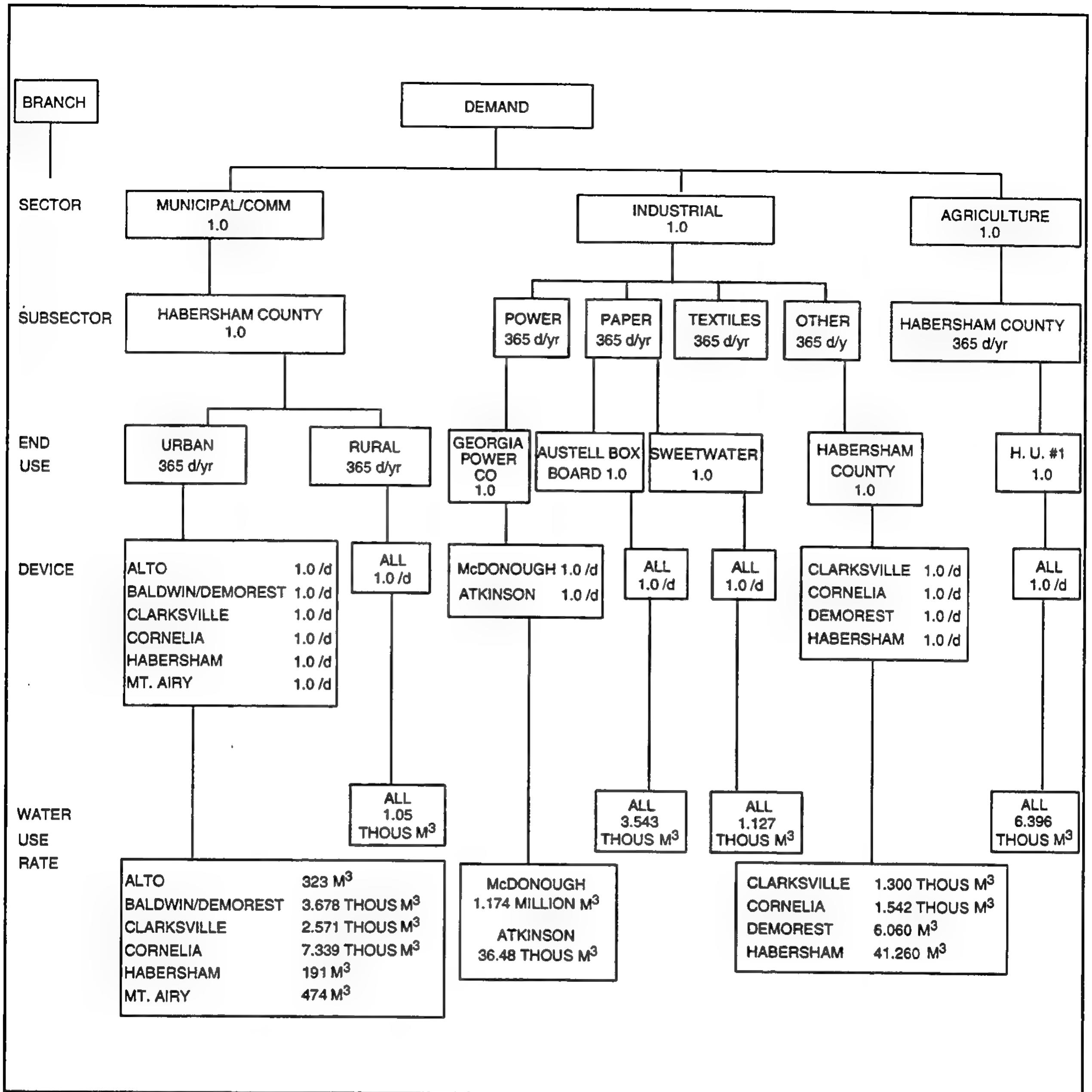


Figure 22: Example of Demand Data Structure, 1990

```
      AREA: UCHAT94M                                              Page  1
  SCENARIO: BASE CASE

        -----  D E M A N D   B R A N C H   D A T A   (at Reporting Years) -----
SECTOR
  SUBSECTOR                      ------------ ACTIVITY LEVELS/WATER USE RATE --------
    ENDUSE                         1990     1995     1999   SCALE  VARIABLE/DEMAND SITE         PROJECTION METHOD
      DEVICE                       ----     ----     ----  ------- ------------------- ---- (If not Interpolation) ---

MUNICIPAL/COMM                    1.000    1.000    1.000
  HABERSHAM COUNTY                1.000    1.000    1.000
    Urban                       365.000  365.000  365.000          days/yr
      Alto                        1.000    1.000    1.000          water use/d
                                323.000  411.062  498.508          M^3 HABERSHAM         Growth Rate:  +4.94%
      Baldwin/Demorest            1.000    1.000    1.000
                                  3.678    4.681    5.677 THOUSAND M^3 HABERSHAM         Growth Rate:  +4.94%
      Clarksville                 1.000    1.000    1.000
                                  2.571    3.272    3.968 THOUSAND M^3 HABERSHAM         Growth Rate:  +4.94%
      Cornelia                    1.000    1.000    1.000
                                  7.339    9.340   11.327 THOUSAND M^3 HABERSHAM         Growth Rate:  +4.94%
      Habersham                   1.000    1.000    1.000
                                191.000  243.074  294.783          M^3 HABERSHAM         Growth Rate:  +4.94%
      Mt. Airy                    1.000    1.000    1.000
                                474.000  603.231  731.557          M^3 HABERSHAM         Growth Rate:  +4.94%
    Rural                       365.000  365.000  365.000          days/yr
      All                         1.000    1.000    1.000          daily use
                                  1.050    1.336    1.621 THOUSAND M^3 HABERSHAM         Growth Rate:  +4.94%
  WHITE COUNTY                    1.000    1.000    1.000
    Urban                       365.000  365.000  365.000          days/yr
      Cleveland                   1.000    1.000    1.000
                                  1.508    1.919    2.327 THOUSAND M^3 WHITE             Growth Rate:  +4.94%
      Helen                       1.000    1.000    1.000
                                194.000  246.892  299.413          M^3 WHITE             Growth Rate:  +4.94%
    Rural                       365.000  365.000  365.000          days/yr
      All                         1.000    1.000    1.000
                                  2.580    3.283    3.982 THOUSAND M^3 WHITE             Growth Rate:  +4.94%
  LUMPKIN COUNTY                  1.000    1.000    1.000
    Urban                       365.000  365.000  365.000          days/yr
      Dahlonega                   1.000    1.000    1.000
                                  2.938    3.739    4.534 THOUSAND M^3 LUMPKIN           Growth Rate:  +4.94%
    Rural                       365.000  365.000  365.000          days/yr
      All                         1.000    1.000    1.000
                                  1.588    2.021    2.451 THOUSAND M^3 LUMPKIN           Growth Rate:  +4.94%
  HALL COUNTY                     1.000    1.000    1.000
    Urban                       365.000  365.000  365.000          days/yr
      Clermont                    1.000    1.000    1.000          water use
                                220.000  279.981  339.541          M^3 HALL              Growth Rate:  +4.94%
      Flowery Branch              1.000    1.000    1.000
                                554.000  705.042  855.026          M^3 HALL              Growth Rate:  +4.94%
      Gainesville                 1.000    1.000    1.000
                                 42.740   54.393   65.964 THOUSAND M^3 GAINESVILLE MWS   Growth Rate:  +4.94%
      Lula                        1.000    1.000    1.000
```

Figure 23: Example of Demand Branch Data Echo Report

Municipal/Commercial/Domestic Sector. This sector includes all domestic, commercial and public uses of water for the cities and rural areas that fall inside the hydrologic boundaries of the study area. Those parts of counties located outside the boundaries of the watershed down to the Fairburn gage are excluded, except in the Atlanta Metropolitan Area where a number of large water supply systems have service areas that extend beyond the watershed boundary. The AMA service area includes major portions of Gwinnett, DeKalb, Cobb, Fulton, Paulding, and Douglas counties as well as portions of Clayton, Rockdale, Fayette, and Henry counties which are completely outside the hydrologic boundaries for the study area. The water demand data for 1990 is taken primarily from plant production summaries provided by the Georgia Department of Natural Resources, 1993. For the county demand sites within the study area, water use projections in millions of gallons per day are categorized by city and by the rural domestic total, according to Georgia Department of Natural Resources, 1984, pp. 68-74. Amounts, sources and destinations of water transfers as well as water use projections were taken from or based on Atlanta Regional Commission, 1991. Wastewater return flow amounts were supplied by USGS, 1993. Appendix A - Data Sources identifies the source of all supply and demand data used in the study.

The demand sectors in the model are organized along the lines of the available data. Within the municipal/commercial/domestic sector, the special demand sites are defined first. Remaining municipal/commercial water use is subdivided for each county that falls within the study area. County use is further subdivided between urban and rural end-uses following along the nature of the available data. Rural use represents self-supplied rural domestic water use within the study area for that county. Urban water use is broken down by each city, where applicable. For those counties making up the AMA, urban use is aggregated into a single AMA end-use, with the exception of three golf courses which are listed separately.

Industrial Sector. This sector includes industrial self-supplied water use as well as industrial water use supplied through public water systems. The data used is from plant production summaries provided by Georgia Department of Natural Resources, 1993, and given in Georgia Department of Natural Resources, 1984, pp. 75-78 and pp. 24-26. In examining individual industrial withdrawal permits three subsectors were identified: power generation, textiles, and paper. Lacking information on the uses of industrial water supplied through existing municipal water systems, an 'other' category was developed to account for these unclassified industrial activities. Under the 'other' subsector, industrial water use data in millions of gallons per day is subdivided by county and city in each county in the study area. No information on production levels, facility size, etc...was gathered at this point in the study to compute driving activity levels. Under the power, textile and paper subsectors, water uses are defined for each known industrial self-supplied facility based on the plant production data. The 'other' industrial use levels for each city come from the aggregate data. In the case of the nine AMA counties, no information on the quantity of publicly supplied water to industrial uses is available. Industrial uses for AMA counties have been aggregated into the municipal/commercial sector, urban end-use category.

Agricultural Sector. Very little information on agricultural water use in the 14 counties covered by this study was readily available. Agricultural water use data projections for 1990 in Georgia Department of Natural Resources, 1984, pp. 79-81 are lumped totals for the portion of each county within the study boundaries. These totals are given in millions of gallons per day and are assumed to include irrigated agriculture, livestock and animal production, etc. The

agricultural sector has been subdivided into county subsectors. Further breakdown of the data into end-uses was not possible with the limited data.

Entering the Data. The water use data from Georgia Department of Natural Resources, USGS, and Atlanta Regional Commission have been converted from gallons per day to cubic meters per day (cmd) for the 1990 production, future projections, and for the permitted withdrawal levels. WEAP expects demand data as annual amounts. This is conveniently handled by entering the conversion factor of 365 (days/year) in either the sector or subsector activity field, so that the original data values can be entered directly into the water use activity level field.

Projecting Future Demands

The concept of projecting future demands in WEAP is illustrated in Figure 24. Future values of water demand can be projected at each level of the branch hierarchy. There are three projection methods to choose from: interpolation, growth rate and drivers/elasticities.

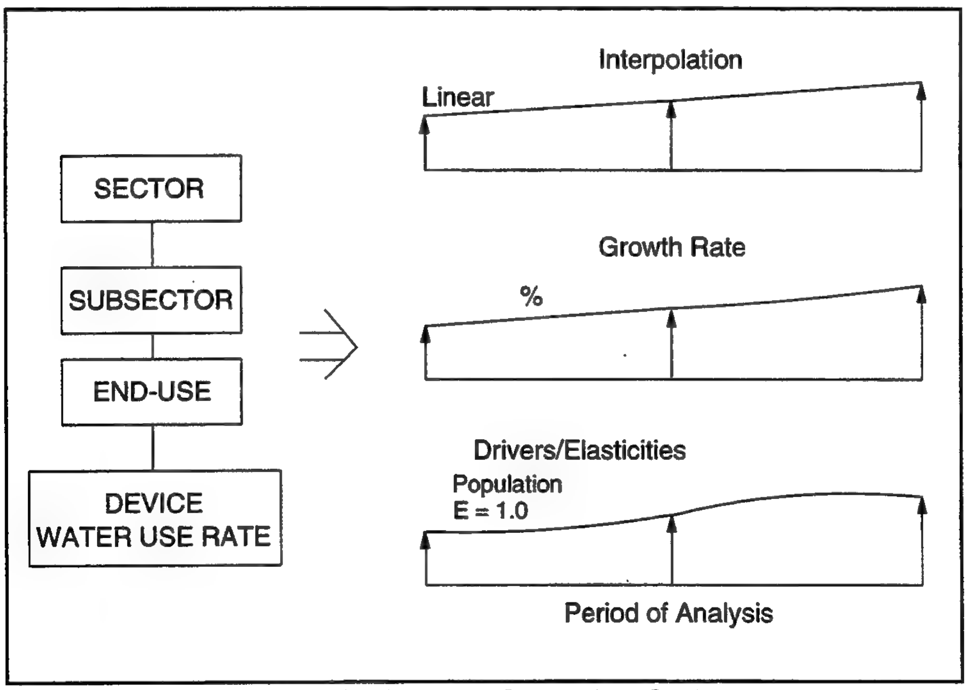


Figure 24: Demand Projection Options

Interpolation. With interpolation demand values are specified for future years and demand values for intermediate years are computed by linear interpolation between the specified years.

Growth Rate. When a growth rate is used it is specified as a percentage and applied to future years beginning with the base year.

Drivers/Elasticities. Drivers are variables which "drive" the future demand for water and may be specified in WEAP to compute future water requirements. Population growth, land use, or economic activity are examples of variables which drive water demand. By specifying a driver for a branch in the demand branch structure, the user projects all demands in that branch at a rate equal to that of the driver. That is, specifying a driver at the sector level will affect all demands in that sector. A maximum of three drivers can be selected for one branch. No drivers are used in the upper Chattahoochee study. A simple percentage growth rate is used in the study for municipal/commercial and most industrial demands outside of the AMA.

The elasticity of water demand is the ratio by which water demand increases as a function of a driver, e.g., as a function of population. Where water demand increases in direct proportion to population (1:1) the elasticity is 1.0. Elasticities other than 1.0 may be specified with any driver, and are used when water use or activity levels do not change in direct proportion to the driving variable. A maximum of three elasticities may be specified. No elasticities are used in the upper Chattahoochee study.

Demand projections for year 1999 are taken from the Atlanta Regional Commission's Water Supply Plan (1991) and interpolated for intermediate years. For areas not covered by ARC's projections, a basic growth rate is used rather than interpolation. This method of demand projection is used because of the absence of recent specific projections for areas outside of ARC's area of interest. The growth rate is an average of ARC's demand projections for the outlying areas of the AMA. The particular ARC projections used to compute the average growth rate were chosen based on similarities in current land use and population density. Figure 25 illustrates the demand projection methods for the upper Chattahoochee study area.

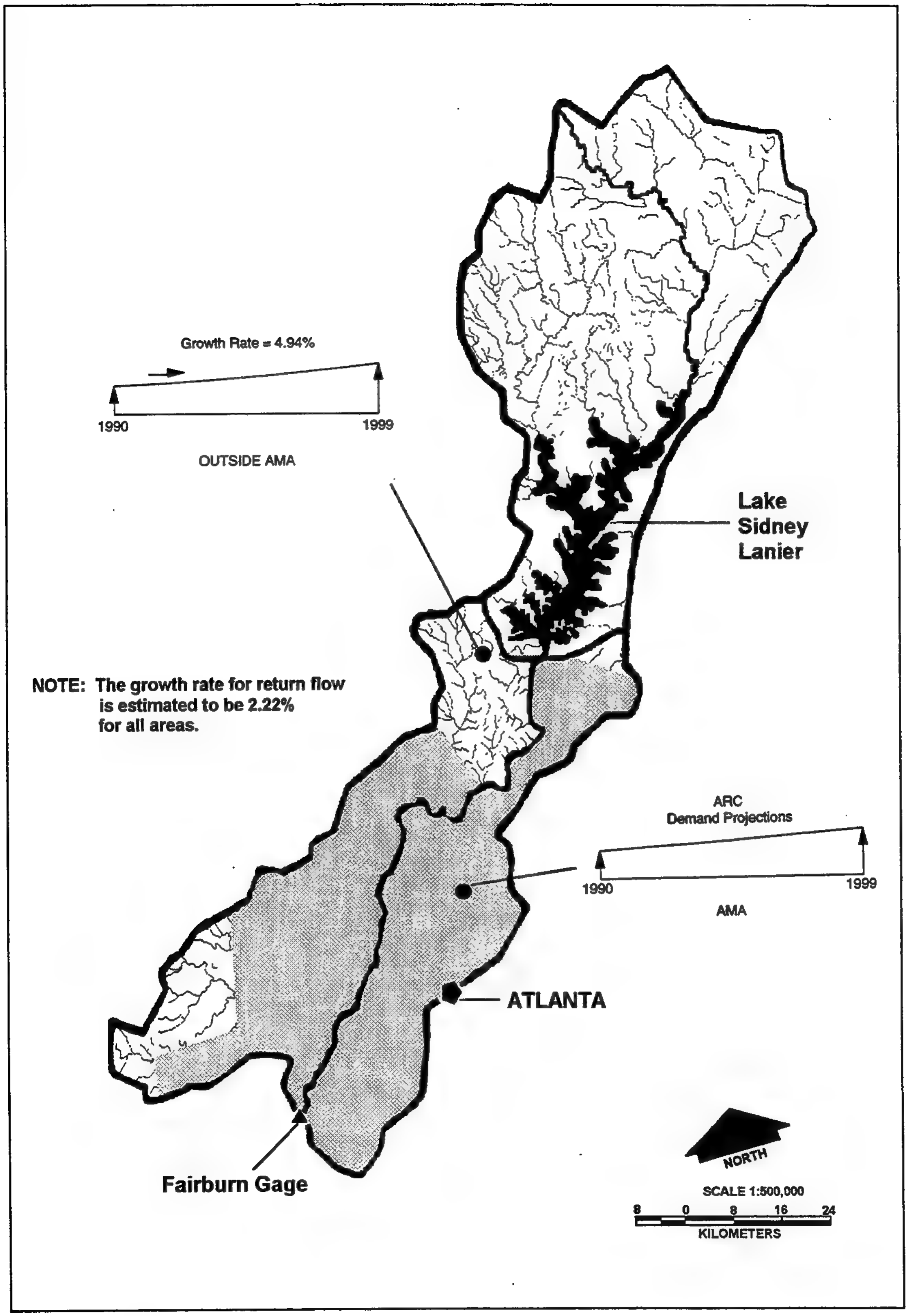


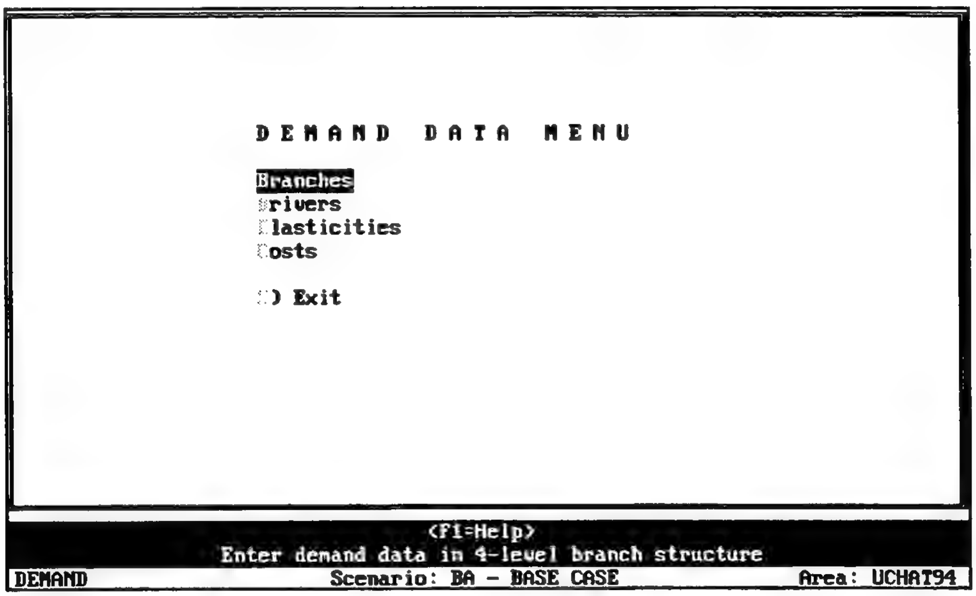
Figure 25: Demand Projections - Upper Chattahoochee River Basin

Costs

Cost/benefit analysis is available in WEAP to compare alternative plans for meeting water demand. The cost is the price of implementing the alternative and the benefit is the benefit of the alternative. The benefit is measured as the "most likely alternative" as described in texts on water resource economics and in the Federal "Principles and Guidelines" (1983). No cost or benefit data are used in the upper Chattahoochee study.

'DEMAND' Menu

The Demand Data Menu is shown below. The Branch Data contain all the demand data for the demand sites in the upper Chattahoochee basin. A complete data set is included in Appendix C - Demand Branch Data. The base case is selected for the demand scenario. Drivers and elasticities are alternative demand projection methods. Costs are used to develop cost/benefit analyses.



Branch Data. The hierarchial organization of the demand data is: Sector, SubSector, End-use, Device and Water Use Rates. The units for each category are aggregated from Water Use Rates to Sector: cubic meters (m^3) per activity (Water Use Rate); cubic meters per day (Device); cubic meters per year (End-use); cubic meters per year (SubSector); cubic meters per year (Sector).

Sector. There are three sector categories municipal/commercial, industrial and agriculture with an activity level value of unity. These are the principal aggregation levels for the water use data.

Sector Branch Data

Sector Name	Base Year 1990	Scale	Activity Levels Driving Activity	Method	1995	Projected Values 1999		
MUNICIPAL/COMM	1.000			INT	.	.	.	.
INDUSTRIAL	1.000			INT				
AGRICULTURE	1.000			INT				

<F1=Help> <F2=Options> <F4=Subsector>
<F9=Show Tree> <F10=Menu>
DEMAND Scenario: BA - BASE CASE Area: UCHAT94

SubSector. The subsector categories for municipal/commercial water use are the counties. These are shown in the Subsector Branch Data Menu. The subsector categories of the industrial sector are: power, paper, textiles and other. The agricultural sector is subdivided by county similar to the municipal/commercial sector.

Subsector Branch Data Page 1 of 2

		Driving Act.					
MUNICIPAL/COMM	1.000		INT	.	.	.	.

Subsector Name	Base Year 1990	Scale	Activity Levels Driving Activity	Method	1995	Projected Values 1999		
HABERSHAM COUNTY	1.000			INT	.	.	.	.
WHITE COUNTY	1.000			INT				
LUMPKIN COUNTY	1.000			INT				
HALL COUNTY	1.000			INT				
FORSYTH COUNTY	1.000			INT				
DAWSON COUNTY	1.000			INT				
GWINNETT COUNTY	365.000		days/yr	INT				
DEKALB COUNTY	1.000			INT				
FULTON COUNTY	365.000		days/yr	INT				
COBB COUNTY	365.000		days/yr	INT				

<F1=Help> <F2=Options> <F3=Sector> <F4=End-use>
<PgUp,F5=Prev> <PgDn,F6=Next> <F9=Show Tree> <F10=Menu>
DEMAND Scenario: BA - BASE CASE Area: UCHAT94

```
                              Subsector Branch Data                    Page 2 of 2
                                         Driving Act.
MUNICIPAL/COMM        1.000                          INT    .      .      .      .



                                         Activity Levels
                  Base Year              Driving                  Projected Values
Subsector Name    1990        Scale      Activity     Method 1995    1999
DOUGLAS COUNTY      1.000                             INT     .      .      .      .
PAULDING COUNTY     1.000                             INT     .      .      .      .
CLAYTON COUNTY*     1.000                             INT     .      .      .      .
ROCKDALE*           1.000                             INT     .      .      .      .
HENRY COUNTY*       1.000                             INT     .      .      .      .
FAYETTE COUNTY*     1.000                             INT     .      .      .      .




        <F1=Help>        <F2=Options>        <F3=Sector>        <F4=End-use>
      <PgUp,F5=Prev>    <PgDn,F6=Next>     <F9=Show Tree>      <F10=Menu>
DEMAND                      Scenario: BA - BASE CASE                Area: UCHAT94
```

End-use. End-use for each county under the municipal/commercial sector is categorized into urban and rural. This is shown in the End-use Branch Data Menu. The activity level is 365 days/year which when aggregated from water use rate gives the number of gallons per year for End-use. In the industrial and agriculture sectors, End-use describes the power companies under the Power category, the paper companies under the Paper category, the counties under the Other category, and the state of Georgia hydrologic unit under the counties (agriculture sector). No textile companies are identified in the upper Chattahoochee basin so there are no End-use, device, or water use rates.

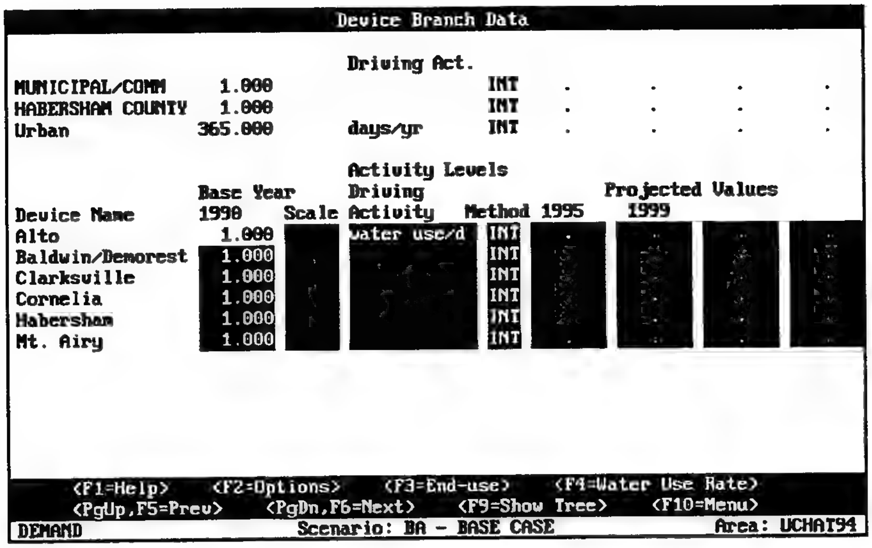
```
                              End-use Branch Data
                                         Driving Act.
MUNICIPAL/COMM        1.000                          INT    .      .      .      .
HABERSHAM COUNTY      1.000                          INT    .      .      .      .

                                         Activity Levels
                  Base Year              Driving                  Projected Values
End-use Name      1990        Scale      Activity     Method 1995    1999
Urban             365.000                days/yr      INT     .      .      .      .
Rural             365.000                days/yr      INT     .      .      .      .

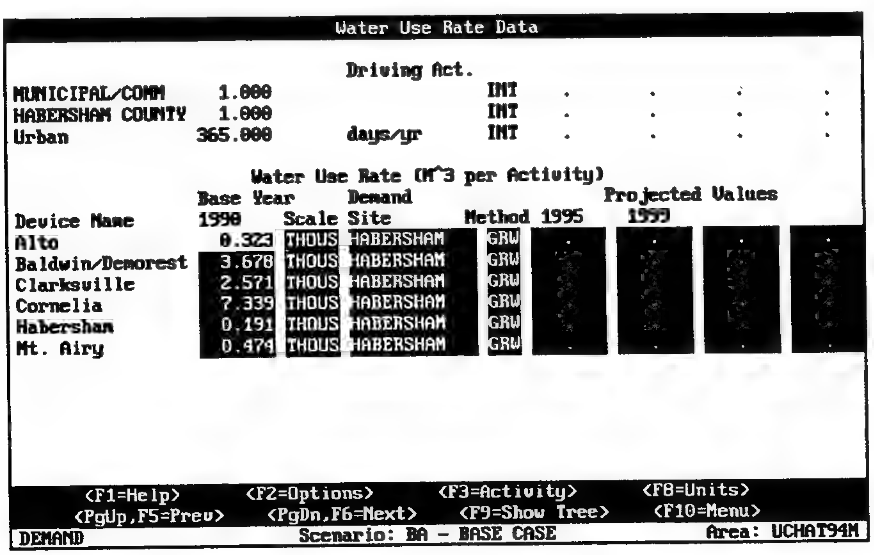



        <F1=Help>        <F2=Options>        <F3=Subsector>     <F4=Device>
      <PgUp,F5=Prev>    <PgDn,F6=Next>     <F9=Show Tree>      <F10=Menu>
DEMAND                      Scenario: BA - BASE CASE                Area: UCHAT94
```

Device. At the device level the cities are represented in the municipal/commercial sector. The cities in Habersham County are identified in the Device Branch Data Menu together with their activity level, 1.0/day. For the industrial sector the specific power plants are identified for the power companies.



Water Use Rate. The water use rate for each device is the most detailed water use category in the branch data. The Water Use Rate Data Menu shows the water use rate in cubic meters for each city in Habersham County. When aggregated to the Device level the water use becomes cubic meters per day and at the End-use, SubSector, and Sector levels the water use is in cubic meters per year. The Water Use Rate menu is also where the demand is tied to a particular demand site.



MONTHLY VARIATIONS, LOSS RATES, CAPACITIES, RETURN FLOWS IN THE 'DISTRIBUTION' PROGRAM

The DISTRIBUTION program covers monthly demand variations, the accounting of losses, transmission capacities, and reuse of the water for all demand sites and sources. Losses in the system are categorized as losses within the demand sites and losses on links from the supply source to the demand site. The capacity of links from the source to the distribution system must also be specified and may become a control on the availability of supply. Reuse within a distribution system may also be specified. This has the effect of reducing the amount of water needed from the supply source. Figure 26 illustrates the relationship between the DEMAND program which represents the annual demand for water; the SETUP program which identifies the demand site and links it to the annual demand data; the DISTRIBUTION program which contains the monthly demand coefficients, loss and reuse rates, and the transmission and return amounts from the river and local supply sources.

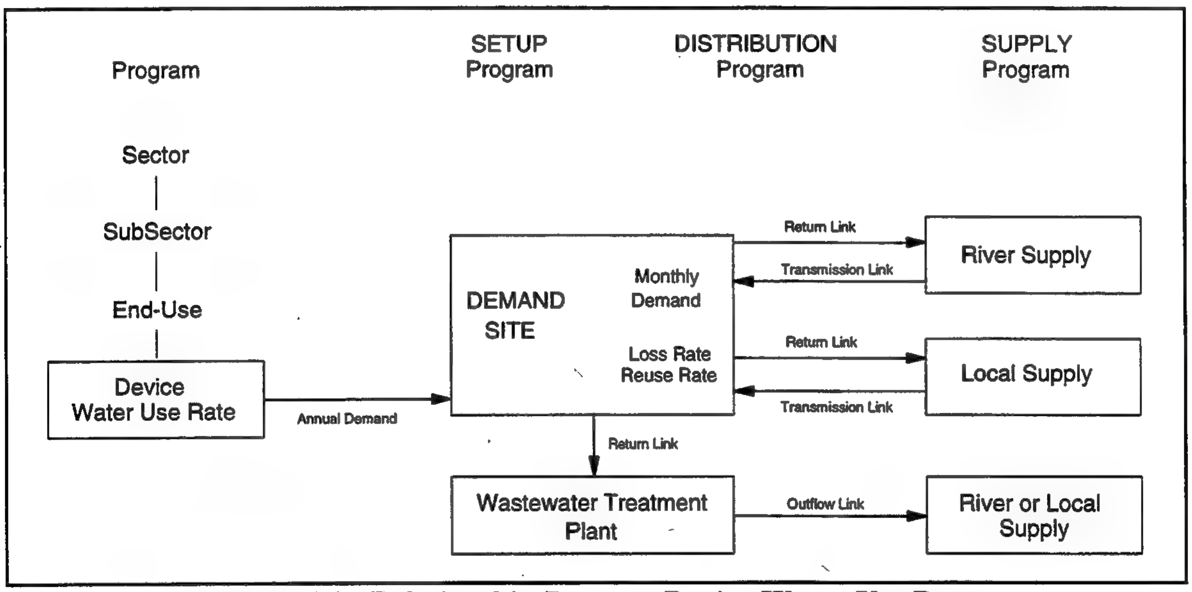


Figure 26: Relationship Between Device Water Use Rate, Demand Site and Water Supplies

<u>Monthly Variation of Annual Demand.</u> Monthly variation data is used to specify seasonal or monthly fluctuations in demand. These variations apply to the demand site's entire demand. Thus, if a demand site represents aggregated demand or distribution systems, the variation should reflect the weighted effects of all demands. This is a point worth considering when thinking about defining demand sites. Individual demands should have similar enough temporal demand patterns over the yearly cycle to be lumped together into one demand site. For the upper Chattahoochee area, these data are based on averages of historical withdrawals or treatment plant production provided by the Atlanta Regional Commission and Georgia Department of Natural Resources. Length of record used to calculate the monthly variation differs from plant to plant. Where records were unavailable or insufficient, an equal monthly distribution of demand is assumed.

Demand Site Losses and Reuse Rates. Demand site losses are losses within a distribution system. The different losses at a demand site are illustrated in Figure 27. Demand site municipal losses include physical leaks, unmetered water use in public parks and buildings, clandestine connections, water used for line flushing, or water use for firefighting. Agricultural losses could be to evaporation or deep percolation. The effect of these losses is to increase demand. In WEAP demand site losses are specified as a percentage of the demand requirement in the branch structure; demand is then increased by the specified percentage. Demand site losses are not estimated for the upper Chattahoochee study.

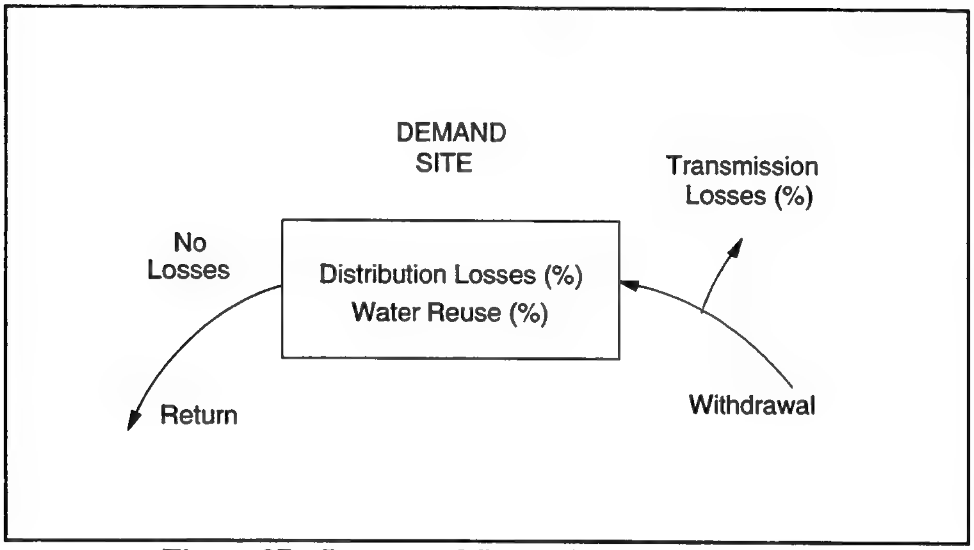


Figure 27: Losses and Reuse for a Demand Site

Municipal reuse of water within a demand site usually involves using treated wastewater for some sort of irrigation. In agriculture, irrigation runoff can be reused for other fields, and in industry water may be recycled for multiple purposes. The effect of reuse is to reduce demand, and is specified in WEAP as a percentage of the final demand. Reuse is not estimated in the upper Chattahoochee study.

Losses and Capacities for Links to Demand Sites. Loss from transmission links is not handled the same in WEAP as loss within a demand site, though the resulting increase in demand is the same. Transmission losses are explicitly reported as such, while losses within the demand sites are lumped into the total demand and are not reported as losses anywhere in the program output. Transmission losses are used in the study rather than losses within the demand sites due to this difference in WEAP's reporting capabilities.

Depending on the purpose of the study and data available, capacity of transmission links can represent physical capacity or legal capacity. The upper Chattahoochee study uses average daily permitted withdrawal levels as the transmission link capacities, except in links to unaccounted surface water which are arbitrarily large so as not to restrict withdrawals from this source.

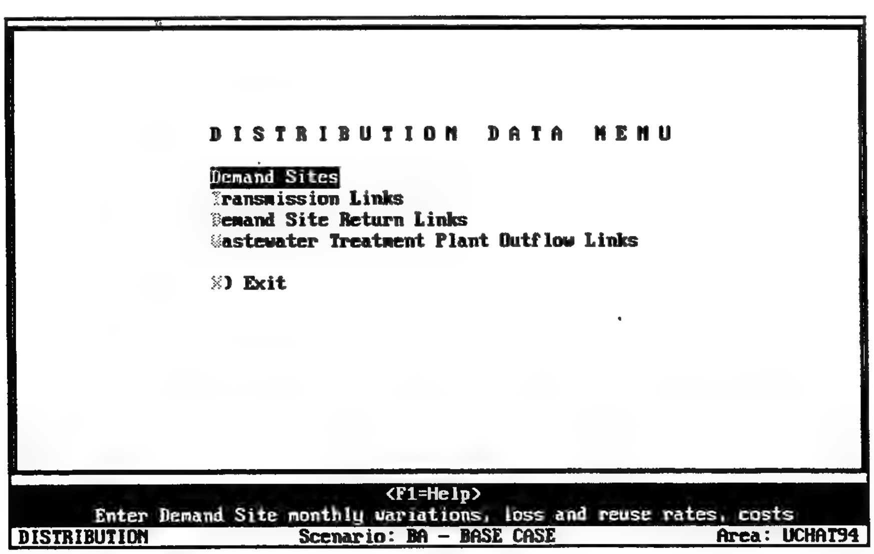
Return Flow from Demand Sites. Return flows from demand sites are specified in WEAP as a percentage of withdrawals or as an absolute value and can be returned to the main river, a tributary wastewater treatment plant, or to groundwater. The amount of the return is added to the river, tributary or wastewater plant flow in the month following the withdrawal. For groundwater return either from a demand site or wastewater plant the return flow may be lagged.

The use of wastewater treatment plants allows for another facility to be modeled and additional flexibility in specifying the location of return flow. In future versions of the program the potential exists to model BOD, storage, and removal rates. Another approach which was tested but not used involves disconnecting the return from the withdrawal by creating a "shadow" demand site to handle just the return flow. The "shadow" site's demand is set equal to the amount of the anticipated return flow from the original site and all of the shadow site's withdrawal is then returned to the desired location, and the return amount from the original demand site is set to zero. This approach was tested to depict the operation of the major wastewater plants in the study area, and was found to work well as long as the original withdrawing demand site does not experience an unexpected deficit. If a deficit occurs less water should be returned, but the "shadow" site continues to function as if the original site's demand had been fully met.

In the upper Chattahoochee study, return flow percentages and destinations for the large demand sites that serve the AMA are based on historical operations of the basin's largest wastewater plants. Return flow percentages and destinations are specified to match as closely as possible the behavior of ten wastewater plants that discharge to or very near the Chattahoochee River (RM Clayton, RL Sutton, Johns, Crooked, Big, Utoy, Entrechment, Sweetwater, Camp Creeks, and South River). Special river nodes are included to represent the locations of the basin's wastewater plants (Mrta Blvd ww rt., wl. CK/BG. jn ww, CB/Dgls Cln/ww, SWEET/Camp WW). Wastewater discharges from the other facilities in the basin are assumed to be part of the confluence flows into the Chattahoochee River.

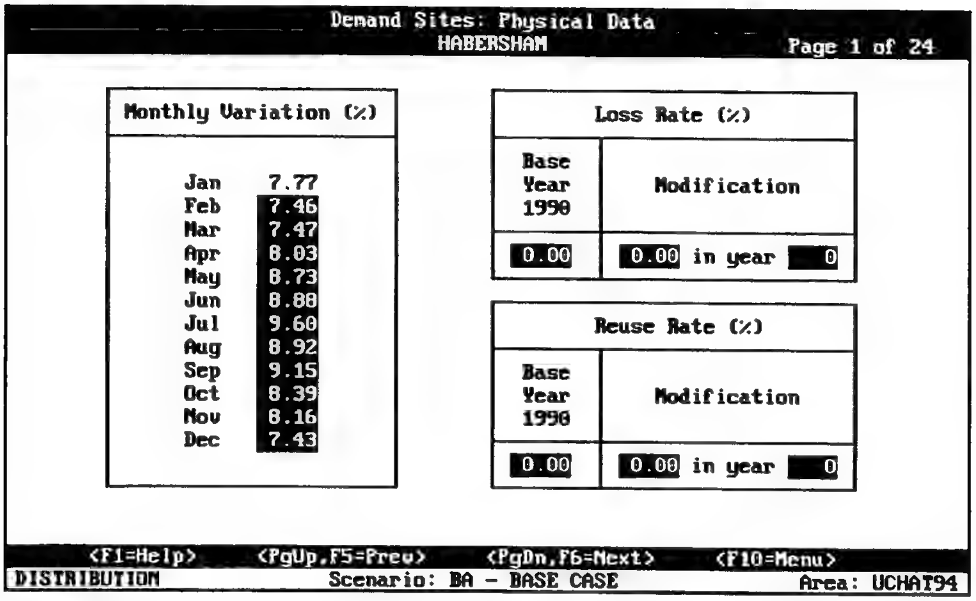
'DISTRIBUTION' Menu

The main menu for the DISTRIBUTION program is shown below.



Demand Sites.

Monthly Variations. In the upper Chattahoochee study monthly variations are based on records of historical operations. For systems where records were not available, an equal monthly distribution is assumed. As an example of the format see the Demand Sites: Physical Data Menu.



Demand Site Losses. Loss and reuse within a demand site are both given as a percentage of final demand, but reuse reduces total demand while loss increases it. Loss and reuse rates are set to zero for all demand sites in the upper Chattahoochee study. The format is illustrated in the Demand Sites: Physical Data Menu.

Reuse Rates. Reuse rates are specified by demand site for the base year and future years as a percentage of final demand. The Demand Sites: Physical Data Menu shows the format for these data, however, values were not specified for the upper Chattahoochee basin.

Transmission Links.

Losses on Links to Demand Sites. Most transmission links have been assigned a loss rate of 5%. One exception is Georgia Power's pipeline to the Chattahoochee which is very short. Any losses from it would quickly reenter the river, so a loss rate of zero has been specified. Atlanta MWS and Atlanta/Fulton-Chattahoochee River have loss rates based on a "system factor" in the Atlanta Regional Commission's Water Supply Plan. All links to the unaccounted surface water source have loss rates of zero since it is a hypothetical accounting aid. The 5% loss rate for all other links is an estimate of actual losses and is not based on hard data. The demand sites and corresponding links in the upper Chattahoochee basin are shown in the Transmission Links: Physical Data Menu.

Capacities on Links to Demand Sites. Link capacities between the demand sites and local supply sources are shown in the Transmission Links: Physical Data Menu. The capacities equal permitted amounts rather than physical capacities, and were input for the base year but are not increased for future years.

Transmission Links: Physical Data
HABERSHAM　　Page 1 of 24

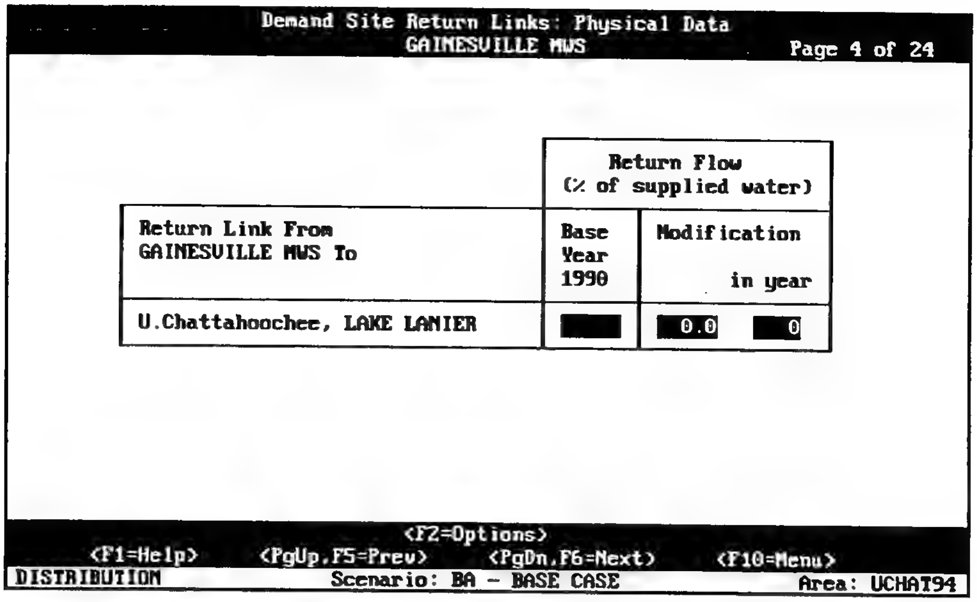
	Loss Rate (%)			Capacity (CMS)		
Transmission Link From HABERSHAM To	Base Year 1990	Modification	in year	Base Year 1990	Modification	in year
Soque Riv 10.5	5.00	0.00	0	0.044	0.000	0
Camp Cr 3.5	5.00	0.00	0	0.123	0.000	0
GW - BLUE R/PDM	5.00	0.00	0	0.052	0.000	0
SW - UNACC'TED	0.00	0.00	0	2.830	0.000	0

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
DISTRIBUTION　Scenario: BA - BASE CASE　Area: UCHAT94M

Return Links.

Return Flows to River and Groundwater. An example of the format for entering return flows is shown in the Return Links: Physical Data Menu. Return flow sources, percentages and destinations in the upper Chattahoochee study are shown in Table 4.

Return Flows to Wastewater Treatment Plants. There are no wastewater treatment plants specified in the upper Chattahoochee study area, rather, return flows go directly to river nodes. In Table 4, the names of the wastewater treatment plants are identified in parenthesis below each return flow destination.



Demand Site Return Links: Physical Data
GAINESVILLE MWS
Page 4 of 24

Return Link From GAINESVILLE MWS To	Return Flow (% of supplied water)	
	Base Year 1990	Modification in year
U.Chattahoochee, LAKE LANIER		0.0 0

<F2=Options>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
DISTRIBUTION Scenario: BA - BASE CASE Area: UCHAT94

Table 4
Return Flow Sources, Percentages, and Destinations

Source of Return Flow	% Returned	Return Flow Destination
Gainesville MWS	50.5%	Lake Lanier (Flat Creek WPCP)
Gwinnett W & S Lake Lanier	74.2%[1]	Marietta Blvd (RL Sutton, RM Clayton)
Gwinnett W & S Chattahoochee River	99.9%	Willeo Creek (Crooked, Big, Johns Creek Wastewater)
Atlanta/Fulton Chattahoochee River	49.1%	Willeo Creek (Crooked, Big, Johns Creek Wastewater)
DeKalb MWS	86%	Cobb/Dgls Co Line (Utoy Creek, S. River, Entrenchment Creek)
Cobb County Chattahoochee River	29.8%	Sweet/Camp WW (Sweetwater, Camp Creek)
Cobb County Lake Allatoona	57.8%	Hwy 20/S. Cobb WW (South Cobb WW)
Atlanta MWS	74.2%	Marietta Blvd (RL Sutton, RM Clayton)
Georgia Power	99.9%	J. Jackson Pkwy (Georgia Power)
East Point MWS	29.8%	Sweet/Camp WW (Sweetwater, Camp Creek)

[1]WEAP stairsteps through each year between the two values.

SPECIFYING WATER SUPPLIES IN THE 'SUPPLY' PROGRAM

The SUPPLY program accounts for all supply sources; this may involve local reservoirs, groundwater, local streams, and the main river, main river reservoirs, all associated tributaries and confluences as well as any other sources of water supply. The SUPPLY program organizes supply data into two groups, one dealing with local supplies and the second covering the main river and tributary supplies.

The supply-demand comparison is carried out in the SUPPLY program whether the river option has been selected or not. Water is supplied to demand sites and return flows are sent to specified destinations according to the system of user-defined priorities and WEAP's allocation algorithm.

Local Supplies

In the upper Chattahoochee local supplies encompass five local streams and one groundwater source. No local reservoirs were identified. An additional category - surface water unaccounted - was created to serve as a means to 'balance' local supply and demand. Each demand site supplied by a local supply is listed in Table 5.

Table 5
Demand Sites and Local Supplies in the Upper Chattahoochee River Study

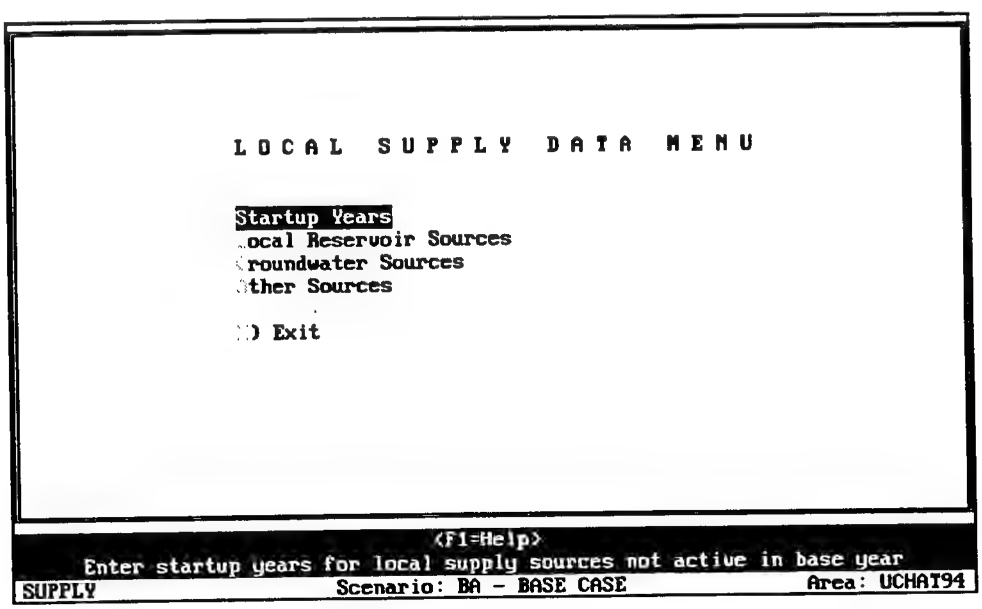
Demand Site	Local Supply
Habersham	Soque River 10.5
	Camp Creek 3.5
	Groundwater - Blue Ridge/PMD
	Surface Water - Unaccounted
White	Turner Creek 0.5
	Groundwater - Blue Ridge/PMD
	Surface Water - Unaccounted
Hall	Groundwater - Blue Ridge/PMD
	Surface Water - Unaccounted
Gainesville MWS	Groundwater - Blue Ridge/PMD
Lumpkin	Yahoola Creek 0.5
	Groundwater - Blue Ridge/PMD
	Surface Water - Unaccounted
Dawson	Groundwater - Blue Ridge/PMD

Table 5, continued
Demand Sites and Local Supplies in the Upper Chattahoochee River Study

Demand Site	Local Supply
Forsyth	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
Gwinnett	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
DeKalb	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
Fulton	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
Cobb	Sweetwater Creek 16 Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
Cobb - Allatoona	Lake Allatoona
Douglas	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted
Paulding	Groundwater - Blue Ridge/PMD Surface Water - Unaccounted

'LOCAL SUPPLY' Menu

The main Local Supply Menu shows the types of local supply sources: local reservoirs, groundwater and other sources.

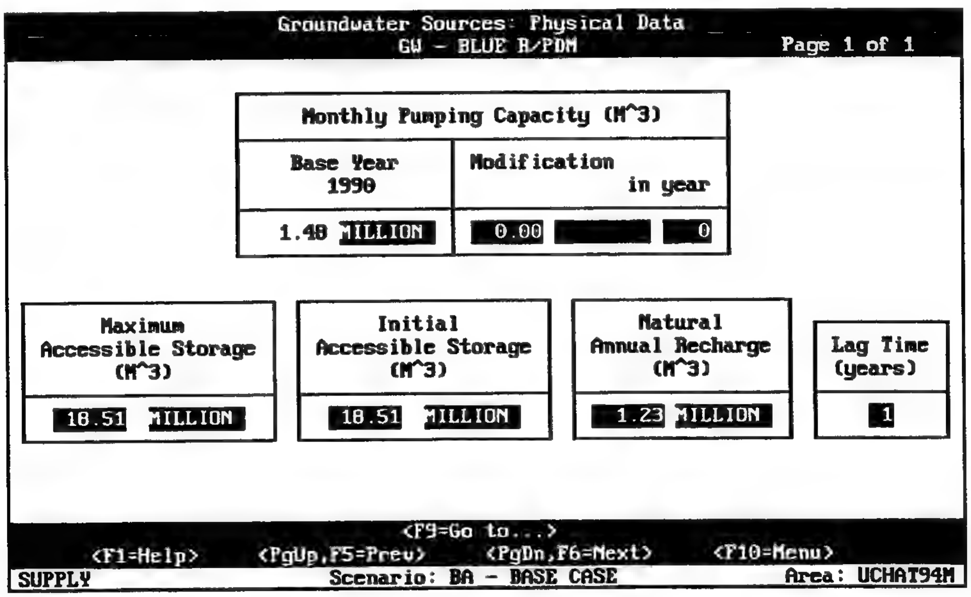


Start-up Years. The Start-up Years provide the option of bringing local supply sources on line at future dates. For the upper Chattahoochee all local sources are active in the base year.

Local Reservoirs. There are no local reservoir supply sources identified for the upper Chattahoochee system. Lake Lanier is a main river reservoir.

Groundwater Sources. The Crystalline Rock aquifer system underlies the upper Chattahoochee River basin. It has been subdivided into numerous formations and mapable units, but all are composed of igneous and/or metamorphic rocks. Thickness ranges from 3 to 3,000 meters. Water occurs in the fractures in the rock and in the pore space of the soil cover. The crystalline rock severely restricts available groundwater quantity. However, groundwater is the only source that is not immediately affected by drought.

There is one groundwater source identified in the basin. The maximum and initial accessible storage, natural annual recharge, lag time for recharge) and monthly pumping capacity are specified as shown in the Groundwater Sources: Physical Data Menu.



Other Sources. The creeks in the upper Chattahoochee basin which serve as supply sources for the demand sites are accounted for in the SUPPLY program as Other Sources. There are four creeks: Soque River, Turner Creek, Camp Creek, and Yahoola Creek; one groundwater source; and one category surface water unaccounted. This latter category provides a means to meet unpermitted demand and quantify deficits. The links between each local supply and demand site are also shown. The twenty years of monthly streamflow data for each local surface water source and the single groundwater source are tabulated in Appendix D - Monthly Local, Headwater, and Confluence Streamflows. These data are stored in a separate HISTSUP.DAT file which may be viewed through the Supply Data Echo Report.

Main River Supplies

The objective of the river option of the SUPPLY program is to account for all withdrawals from and discharges to the Chattahoochee River while interacting with the local supplies at withdrawal and reservoir nodes. Data required for this accounting are similar to that for standard reservoir simulation programs: streamflow at the headwaters and confluences, physical features of the reservoirs, reservoir and run-of-river hydropower generating specifications, reservoir release requirements, and withdrawals, evaporation, and instream requirements along the river.

Demand sites and their respective river supply and node and listed in Table 6. Headwater and confluence flows are presented in Appendix D. These data are stored in the HISTRIV.DAT file in WEAP, and like the HISTSUP.DAT, they may be viewed through the Supply Data Echo Report. There are no diversion nodes. The remainder of the menu items are discussed below.

Table 6
Demand Sites and River Supplies in the Upper Chattahoochee River Study

Demand Site	River Source and Node
Gainesville MWS	Lake Lanier - Lake Lanier
Buford MWS	Lake Lanier - Lake Lanier
Gwinnett W & S Lake Lanier	Lake Lanier - Lake Lanier
Forsyth	Lake Lanier - Lake Lanier
Gwinnett W & S Chattahoochee River	Chattahoochee River - Upstream Suwanee Crk
Atlanta/Fulton County	Chattahoochee River - Downstream John's Crk
DeKalb MWS	Chattahoochee River - Holcomb Bridge Rd
Roswell MWS	Chattahoochee River - Roswell Rd Bridge
Cobb - Allatoona[1]	Chattahoochee River - Johnson Ferry Rd
Cobb - Chattahoochee	Chattahoochee River - Johnson Ferry Rd
Atlanta MWS	Chattahoochee River - Upstream Peachtree Crk
Georgia Power	Chattahoochee River - J. Jackson Pkwy
East Point MWS	Chattahoochee River - Cambellton 166

[1]Cobb - Allatoona's link to the Chattahoochee River has a capacity of zero and cannot transmit water from the river, but is necessary to allow return flows to be sent to the Chattahoochee River.

Reservoir. Figure 28 illustrates the reservoir zones modeled by WEAP. The reservoir operation is completely at or below the top of conservation, that is, there is no flood control operation. The buffer zone is established to reduce reservoir releases when the conservation storage is low. This is handled in WEAP by specifying a buffer coefficient which when multiplied by storage in the buffer pool gives the water available for release.

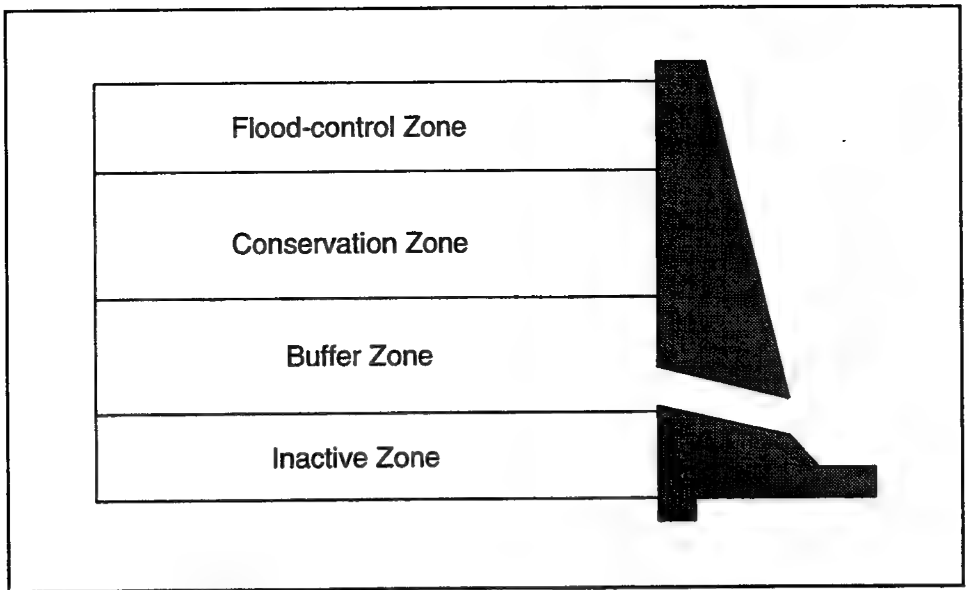


Figure 28: Typical Reservoir Storage Zones

Instream Requirements. The concept of instream flow requirements in WEAP is illustrated in Figure 29. Up to five river reaches may have instream requirements and each reach may have up to three flow specifications, for example, for purposes such as water quality, fishery and recreation. A reach is defined as the segment of the river between any two nodes. The reaches with the requirements may be located anywhere along the river. The instream requirements do not directly influence water releases from the reservoir, rather they are for reporting purposes where river flow is compared with the requirements for different purposes. The minimum downstream requirement which is specified at the end of the subbasin is the only instream requirement for which the reservoir operates.

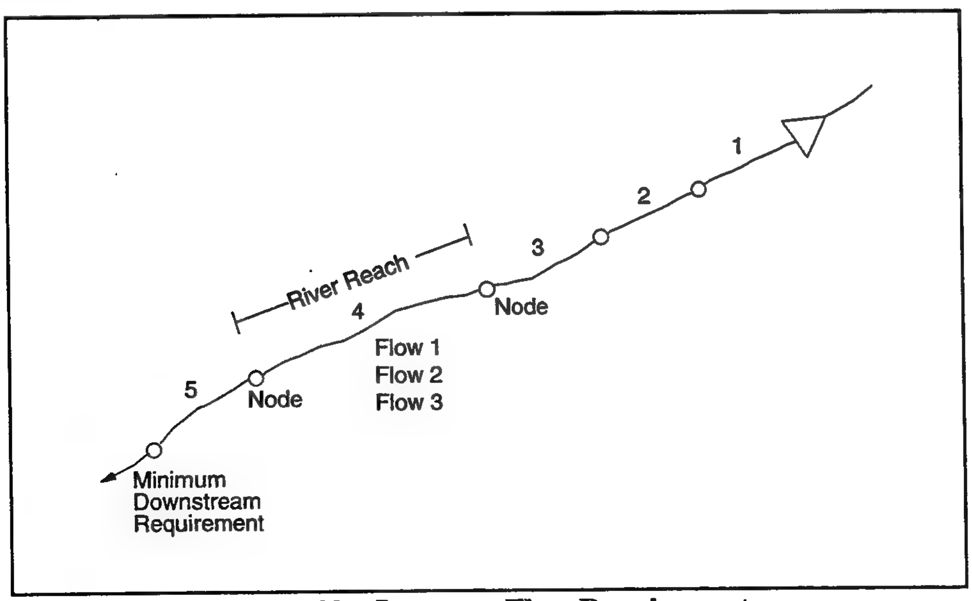


Figure 29: Instream Flow Requirements

The instream requirements for the Chattahoochee River are shown in Figure 30. Generally, instream flow requirements are set by the 7Q10 streamflow. This is the average 7-day flow that has a recurrence probability of 1 in 10 years. There are two 7Q10 instream requirements included in the model for reporting purposes, 25-48 m^3/s (900 cfs) immediately above the intake for the Atlanta MWS, and 24.21 m^3/s (855 cfs) just downstream of Georgia Power. There are two additional water quality requirements: a Congressionally mandated 18.41 m^3/s (650 cfs) flow at the City of Atlanta and a minimum flow of 21.24 m^3/s (750 cfs) below the intake for the Atlanta MWS and above the confluence of Peachtree Creek set by the Georgia Department of Natural Resources. None of these requirements 'drive' the operation of the river system, rather they are for reporting purposes with which to compare streamflow.

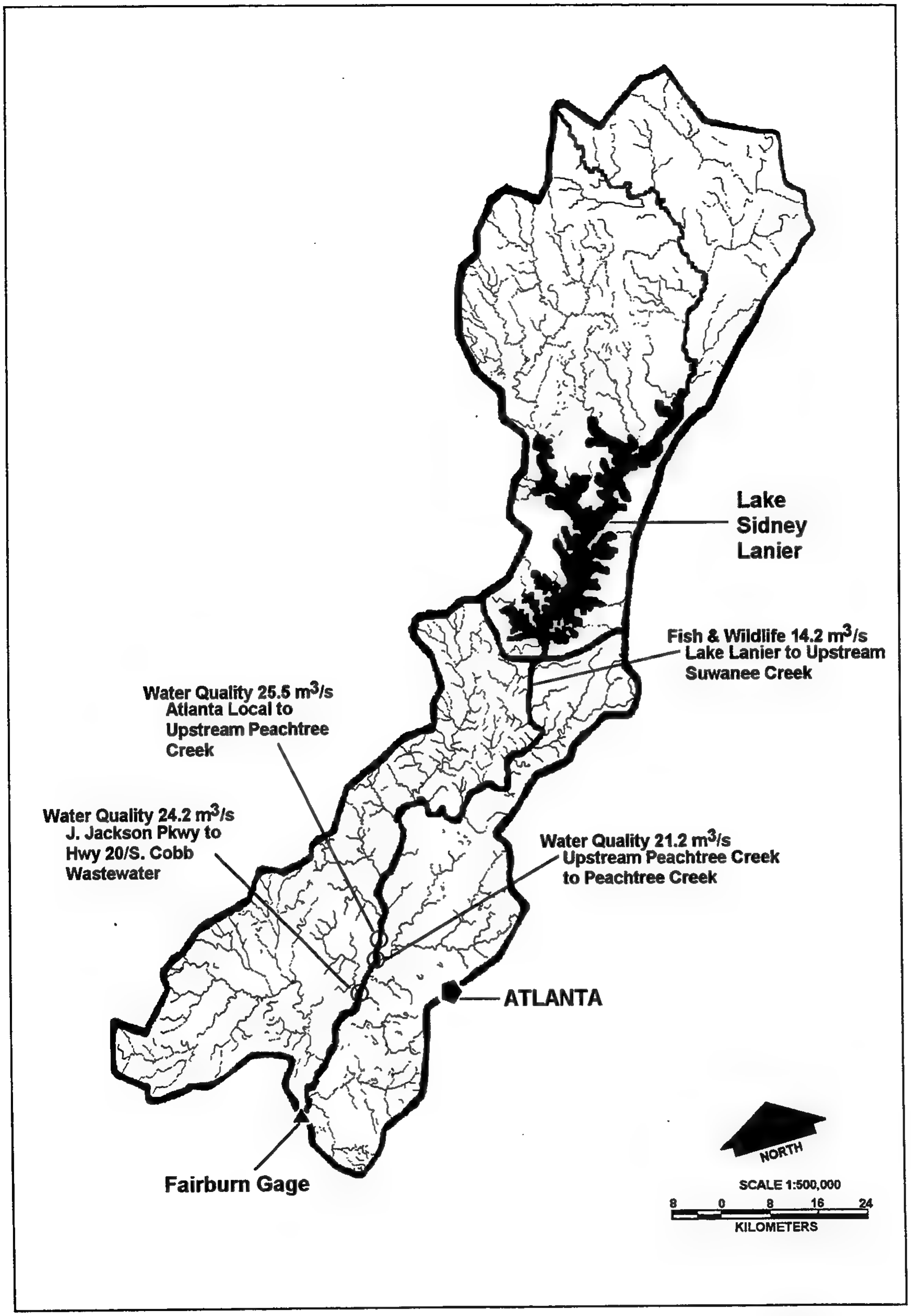


Figure 30: Instream Flow Requirements - Upper Chattahoochee River Basin

River/Reservoir Gains and Losses. Losses from and gains to the river and reservoir system are shown in Figure 31. Where a percentage (%) is shown the loss is computed as a percentage of the river flow. Otherwise the loss or gain is specified as a monthly absolute value.

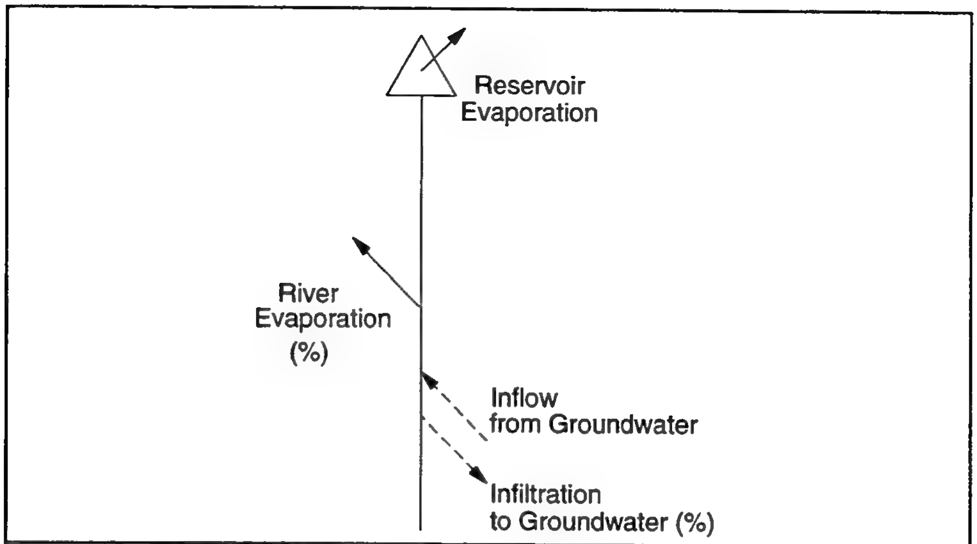
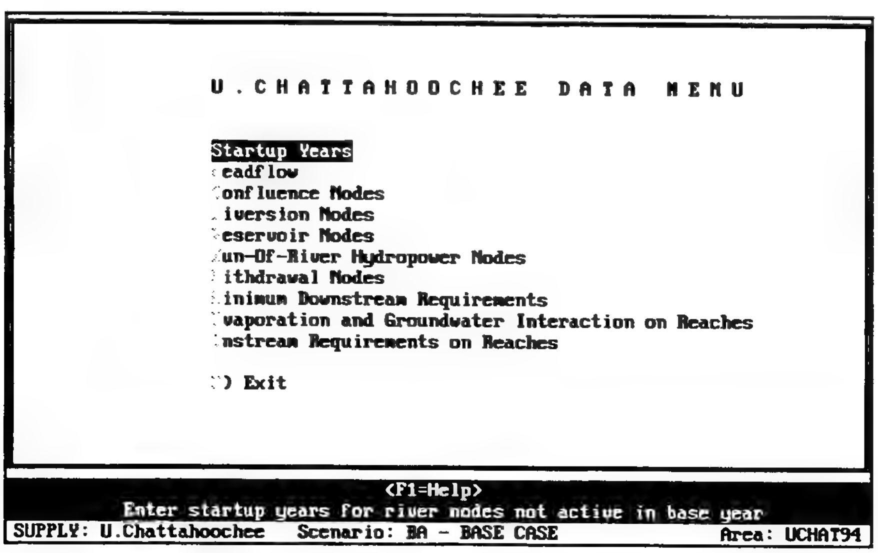


Figure 31: River/Reservoir Gains and Losses

Losses and gains assumed for the upper Chattahoochee watershed are shown in Figure 32. Reservoir evaporation was estimated using a monthly evaporation rate. River evaporation is a percentage of the river flow and varies by month but is assumed the same for each reach. Groundwater infiltration and inflow was assumed to be accounted for in the estimate of ungaged runoff. Also shown in Figure 32 is the 5% transmission losses assumed for all demand sites and the fact that losses and reuse were not estimated at demand sites.

'RIVER' Menu

The Main River Menu from the SUPPLY program is shown below. For the upper Chattahoochee study all nodes associated with the river are active in the base year.



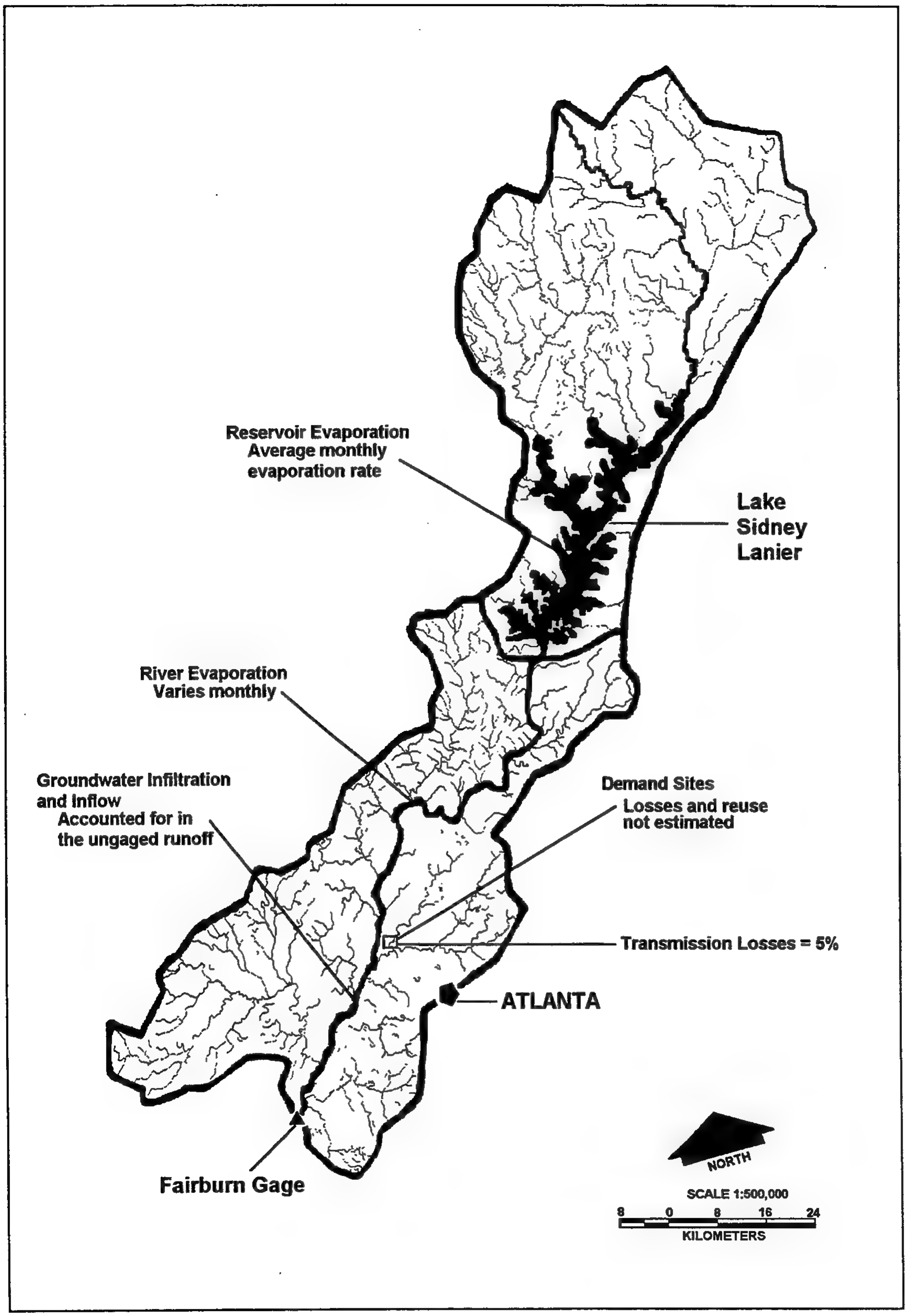


Figure 32: Losses, Gains and Water Reuse - Upper Chattahoochee River Basin

Reservoir Node. There is one reservoir on the main river, Buford Dam - Lake Sidney Lanier, in the upper Chattahoochee watershed. Data describing the storage zones, volume-elevation-area relationships, and evaporation are shown in the Reservoir Nodes: Physical Data and Operation Data Menus. Lake Lanier serves flood control, fish and wildlife, navigation, hydroelectric power, water supply, water quality and recreation. The data required to define the hydropower generation at Buford Dam are described in the Reservoir Nodes: Hydropower Data Menu.

Reservoir Nodes: Physical Data
LAKE LANIER
Page 1 of 6

Base Year 1990

Total Storage (M^3): 3151.640 MILLION

Initial Storage (M^3): 2365.580 MILLION

V-S-E Function: Volume (M^3) Scale: MILLION	Surface Area (M^2) Scale: MILLION	Elevation (M) Scale:		Net Evaporation (MM)
3151.640	190.933	330.710	Jan	+44.20
2412.717	155.969	326.441	Feb	+55.63
2273.275	149.789	325.526	Mar	+82.80
2138.645	143.882	324.612	Apr	+112.01
1926.521	134.505	323.088	May	+170.43
1728.587	125.541	321.564	Jun	+186.18
1543.611	116.793	320.040	Jul	+191.52
1372.455	107.719	318.516	Aug	+48.51
1214.873	98.805	316.992	Sep	+83.31
1070.618	90.816	315.468	Oct	+69.09
			Nov	+83.06
			Dec	+64.52

<F9=Go to...>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

Reservoir Nodes: Operation Data
LAKE LANIER
Page 2 of 6

Base Year 1990

Top of Inactive Pool (M^3): 1070.618 MILLION

Buffer Zone Coefficient: 0.33

	Top of Conservation Pool (M^3) Scale: MILLION	Top of Buffer Pool (M^3) Scale: MILLION	Reservoir Requirement (M^3) RECREATION Scale: MILLION
Jan	2365.578	2138.645	0.000
Feb	2365.578	2227.617	0.000
Mar	2365.578	2273.275	0.000
Apr	2389.147	2365.578	0.000
May	2412.717	2389.147	2183.069
Jun	2412.717	2227.617	2183.069
Jul	2412.717	2205.405	2183.069
Aug	2412.717	2183.069	2183.069
Sep	2412.717	2138.645	2183.069
Oct	2400.932	2095.332	0.000
Nov	2377.362	2095.332	0.000
Dec	2365.578	2052.142	0.000

<F9=Go to...>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

Reservoir Nodes: Hydropower Data
LAKE LANIER — Page 3 of 6

Base Year 1990

Turbine Flow (CMS)	
Maximum	Minimum
339.840	11.330

Tailwater Elevation (M): 281.330

	Target Energy Demand (MWH) Scale:	Plant Factor (%)	Efficiency (%)
Jan	0.000	99.00	85.00
Feb	0.000	99.00	90.00
Mar	0.000	99.00	90.00
Apr	0.000	99.00	85.00
May	0.000	99.00	80.00
Jun	0.000	99.00	80.00
Jul	0.000	99.00	75.00
Aug	0.000	99.00	75.00
Sep	0.000	99.00	75.00
Oct	0.000	99.00	75.00
Nov	0.000	99.00	80.00
Dec	0.000	99.00	80.00

<F9=Go to...>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

Run-of-River Hydropower Node. Downstream from Buford at Morgan Falls there is run-of-river hydropower generation. The specifications necessary to compute hydropower generation for this facility are presented in the Run-of-River Hydropower Nodes: Physical Data Menu.

Run-Of-River Hydropower Nodes: Physical Data
MORGAN FALLS — Page 1 of 2

Base Year 1990

Turbine Flow (CMS)	
Maximum	Minimum
141.600	26.904

	Target Energy Demand (MWH) Scale:	Plant Factor (%)	Efficiency (%)	Fixed Head (M)
Jan	0.000	99.9	80.0	15.2
Feb	0.000	99.9	80.0	15.2
Mar	0.000	99.9	80.0	15.2
Apr	0.000	99.9	80.0	15.2
May	0.000	99.9	80.0	15.2
Jun	0.000	99.9	80.0	15.2
Jul	0.000	99.9	80.0	15.2
Aug	0.000	99.9	80.0	15.2
Sep	0.000	99.9	80.0	15.2
Oct	0.000	99.9	80.0	15.2
Nov	0.000	99.9	80.0	15.2
Dec	0.000	99.9	80.0	15.2

<F9=Go to...>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

Minimum Downstream Requirements. The minimum downstream requirements are a set a monthly flows that must be maintained after each group of nodes or sub-basin on the river or tributary. Each reservoir node begins a new group or sub-basin, except for the first and last nodes on the river which automatically begin and end a sub-basin. The downstream requirement is a controlling factor in the program because it automatically receives first priority, ahead of all upstream demand site requirements. For the upper Chattahoochee there is only one sub-basin,

beginning at Lake Sidney Lanier and ending at the Fairburn Gage. The minimum monthly downstream requirements below the Fairburn Gage are shown in the Minimum Downstream Requirement Menu. The average monthly flow for the 10-year period of analysis (1980-1989) was used for the Base Case in the WEAP analysis.

Minimum Downstream Requirements
(Requirement after FAIRBURN LOCAL) Page 1 of 1

Minimum Downstream Requirements (CMS)

	Base Year 1990 Scale:	Modification in year 0 Scale:
Jan	89.548	0.000
Feb	104.274	0.000
Mar	107.814	0.000
Apr	111.439	0.000
May	91.020	0.000
Jun	69.809	0.000
Jul	75.671	0.000
Aug	82.751	0.000
Sep	71.055	0.000
Oct	66.410	0.000
Nov	68.393	0.000
Dec	78 588	0 000

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10-Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

<u>Evaporation and Groundwater Interaction.</u> Evaporation from Lake Lanier is accounted for by applying an average monthly evaporation rate to the surface area of the lake at the beginning of the month. The average rate is based on correlation between historical pan evaporation rates in the surrounding area and coordinated with NOAA Technical Reports 33 and 34 specifying seasonal evaporation rates for the lower 48 states.

There are twenty-five reaches from Lake Sidney Lanier to Fairburn Gage. Surface evaporation and groundwater flow to and from the river are necessary elements of the water accounting in the river option. The Evaporation and Groundwater Interaction Menu illustrates the structure of the data required for the first two reaches. Surface evaporation and flow from the river to the groundwater aquifer are both specified as a monthly percentage of river flow. These are losses from the river system. Gains to the system are accounted for by flow from the adjacent aquifer to the river. These are specified monthly in units of volume, acre-feet in this case. For the upper Chattahoochee basin groundwater interaction to and from the river are assumed to be accounted for in the ungaged runoff coming into the Chattahoochee.

Evaporation and Groundwater Interaction on Reaches
LAKE LANIER to US SUWANEE CRK Page 1 of 26

	Surface Evaporation (% of river flow)	Groundwater Interaction GW Source:	
		River to GW (% of river flow)	GW to River M^3
Jan	0.01	0.00	0.000
Feb	0.01	0.00	0.000
Mar	0.02	0.00	0.000
Apr	0.02	0.00	0.000
May	0.04	0.00	0.000
Jun	0.04	0.00	0.000
Jul	0.04	0.00	0.000
Aug	0.04	0.00	0.000
Sep	0.02	0.00	0.000
Oct	0.02	0.00	0.000
Nov	0.01	0.00	0.000
Dec	0.01	0.00	0.000

<F9=Go to...>
<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

<u>Instream Requirements.</u> Instream flow requirements are specified by reach and by purpose in the following four Instream Requirement Menus. These are the minimum flow requirements in different reaches of the river for water quality, recreation, and fish and wildlife by month in cubic meters per second (m^3/s).

Instream Requirements on Reaches
Page 2 of 5

Reach: ATLANTA LOCAL to US PEACHTREE CR

Purpose / Note / Scale	WATER QUALITY / 7Q10 flow / (CMS)	(CMS)	(CMS)
	Minimum Flow	Minimum Flow	Minimum Flow
Jan	25.488	0.000	0.000
Feb	25.488	0.000	0.000
Mar	25.488	0.000	0.000
Apr	25.488	0.000	0.000
May	25.488	0.000	0.000
Jun	25.488	0.000	0.000
Jul	25.488	0.000	0.000
Aug	25.488	0.000	0.000
Sep	25.488	0.000	0.000
Oct	25.488	0.000	0.000
Nov	25.488	0.000	0.000
Dec	25 488	0 000	0 000

<F1=Help> <PgUp,F5=Prev> <PgDn,F6=Next> <F10=Menu>
SUPPLY: U.Chattahoochee Scenario: BA - BASE CASE Area: UCHAT94M

UNDERSTANDING THE OPERATING CRITERIA

Priorities

Priority Between Local and River Sources. When both local and river sources are connected to a single demand site, the user must select which category of source to withdraw from first: the local sources or the river or tributary sources. Then, within the selected category priorities are addressed. For example, if local supplies are selected as the first priority each local supply priority is met before water is withdrawn from a river (or tributary) source. When all local supplies have an equal priority and the demand is less than the supplies, WEAP allocates from each source in the order it has been entered in the SETUP program. For example, if three supplies have priority 1 the demand is met first from the supply that was first entered in the SETUP program. When that supply is exhausted the demand is next met with the supply that was next entered into the SETUP program and so on. If all local supplies are assigned the same priority and the supply is insufficient to meet the aggregate demand, WEAP will balance all competing demands so that an equal percentage of each is met.

Priorities for withdrawals from rivers and tributaries are considered together with tributaries taking precedence. For example, if both a river node and tributary node have the same priority, the tributary takes precedence.

Priority Between Multiple Demand Sites on Local Sources. A priority system can also be arranged between demand sites connected exclusively to local sources. To set up such a system, the highest priority demand site must have the highest priorities and demand sites with lower priority must have progressively lower link priorities. For example, a highest priority site is connected to three sources which are assigned priorities 1, 2, and 3. A lower priority demand site would begin priority at 4, and so on. Up to 99 priorities can be used.

Minimum Downstream Requirement

The minimum downstream requirement is an important parameter in the water supply allocation algorithm because it is the only driving variable for the river simulation. It is distinct from instream requirements which are not used as driving variables in the program, but are only compared with calculated flows in reporting tables. The minimum downstream requirement has first priority, over all demand sites on the river; if it is not met, no water will be allocated to upstream demand sites. There is a set of user-entered monthly downstream requirements for each group of nodes or sub-basin on the river or tributary. A sub-basin is defined by two successive reservoir nodes, and/or the first and last nodes on the river. The operation and amount of storage in the reservoir at the head of the sub-basin are strongly influenced by the minimum downstream requirement. Raising the minimum downstream requirement will draw the reservoir down faster.

The minimum downstream requirement does not appear in any reporting tables, nor is there any explicit indication that it has or has not been met. To make the minimum downstream requirement visible in the reporting tables, the user can specify equivalent or similar values as an instream requirement for the reach immediately upstream of the final node in the sub-basin. The instream requirement table can then be used to directly review the calculated flows versus the minimum downstream requirement.

Defining Demand and Demand Sites

Because WEAP's reporting options only permit viewing demand and supply results in a set of specific tabular and graphical formats based on demand sites, it is important that the demand sites be defined carefully. Depending on how the demand sites are defined, the information immediately available from the output tables will vary. The connection between annual demand entered in the branch structure and the supply sources is at the demand site level. Demand must be tied to a demand site at the lowest or "device, water use rate" level of the branch structure, and the demand site is in turn linked to one or more supply sources in the SETUP program. The demand sites are identified in the SETUP program and serve as a means to group water users with common characteristics, e.g. geographic area or season pattern of water use. The demand site basically consists of one or more water devices which in turn are linked to the demand branch structure defined in the DEMAND program.

The demand site also serves as a vehicle for conversion of the annual demand (base year and projected future year demand) to monthly values in the DISTRIBUTION program, according to the user-specified schedule of monthly variations for the demand site. Losses and reuse of water at the demand site may also be taken into account in the DISTRIBUTION program. The monthly values are then met by the River and Local Supplies in the SUPPLY program. Because of the connections both vertically (Sector to Device water use rate) and horizontally (Device water use rate to Demand Site to Supply), care should be taken in defining the branch structure and demand sites.

In addition to reporting in terms of demand sites, the DEMAND program has the capability to report in terms of the sectors, subsectors, etc. The SUPPLY program can show results in terms of the local supply sources or river nodes, but many of the output tables are based on the demand site. The demand site is the one common reporting format that unites all component programs of WEAP. Up to 65 demand sites can be specified in WEAP.

Details of demand contained in the demand branch structure will not be reflected in DISTRIBUTION, SUPPLY, and EVALUATION output tables if the details are lumped into a single demand site. For example, a breakdown of a county's demand into agricultural, industrial, and municipal components in the DEMAND program will not appear in the other programs' output tables if all three components are combined in a single demand site representing the entire county.

The questions answered by output information depend on the nature of the demand sites, and to a lesser extent on how the demand branch structure's sectors, subsectors, etc., have been defined. If the primary questions are based on spatial distribution of demand, the demand sites and branch structure should reflect geographic units such as counties. Defining demand sites in this way may sacrifice information on a specific supply source or use of water if the demand site is connected to multiple sources or encompasses multiple uses. If the primary questions relate to a specific source, then demand sites should be defined that withdraw only from that one source, or have it as the first priority source. In the upper Chattahoochee study, demand on Lake Lanier and the Chattahoochee River is of interest. Therefore demand sites representing actual withdrawal facilities were defined to develop a clear picture of the demand on those particular sources at specific points. Information on the areal coverage provided by the actual withdrawal facilities or

the eventual uses of the water (industrial, municipal) is not as detailed as a result of defining the demand sites in this manner.

A second issue in the upper Chattahoochee case study was how to assign demand for water transfers. For this study, transfer destinations were shown in the demand branch structure at the sub-sector level and connected to the origin of the transfer at the "Device water use rate" level, assigned to the demand site representing the withdrawing facility. The result is an accurate picture of supply-demand interaction by source, at the points of withdrawal. This picture, however, sacrifices information on the destinations of the transfers. An alternative structure might have been to define separate demand sites for each transfer destination and connect all of these sites to the same river node. This arrangement would have allowed explicit supply-demand reporting on the transfer destinations.

The format of the available data plays a role in determining the organization of the demand sites and branch structure, but the user can shape the model as desired with a clear concept of the questions to be answered.

Simplifying Tributaries as Confluences

Sometimes, it may be expedient to represent a tributary as a simple confluence which does not require data on headflow, evaporation, groundwater interaction, and minimum downstream requirements. Such a situation may arise when a single demand site withdraws and returns water on a stream that joins the main river. In WEAP such a simple configuration would normally be connected to the main river with the tributary option. However, a demand site cannot be included if the stream is represented with a confluence flow because a confluence cannot interact with a demand site. And the stream cannot be a local supply source because local sources are not connected to the river/tributary system and do not allow return flow.

One way to use a confluence is to redefine the tributary headflow as a local source and link this local source to the demand site. At the river a confluence node is used and the inflows can be adjusted to take into account the withdrawals and returns associated with the demand site. If the withdrawal from the tributary has a minor effect on the flow, the adjustment might be made by subtracting an average estimated withdrawal amount from the headflow, or neglecting it all together. If greater accuracy is desired the actual configuration can be run to develop a set of flows that reflects the withdrawals and returns at the demand site. The resulting set of flows can then be used as the inflows at the confluence point, and the tributary headflow becomes the set of local source flows. Figure 33 shows a schematic representation of the simplified configuration.

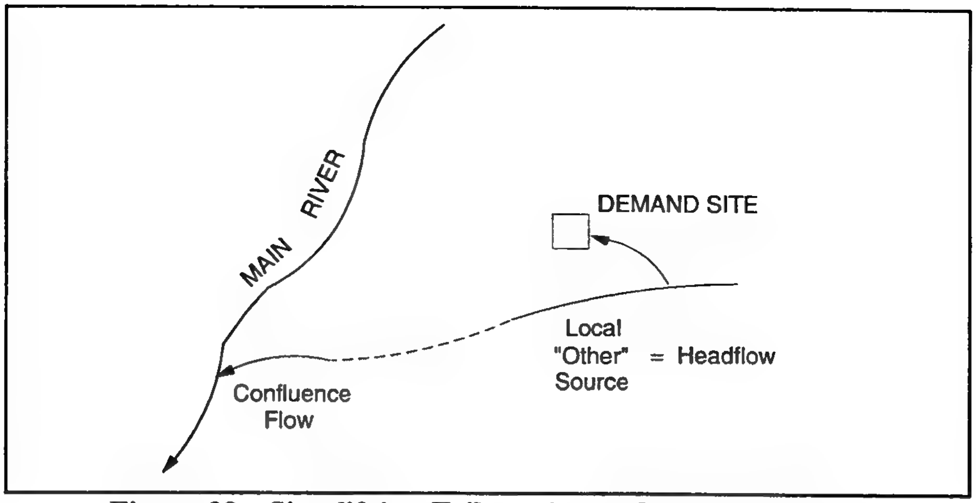


Figure 33: Simplifying Tributaries as Confluence Flows

Distinctions in Supply Sources

Supply sources are divided into two main categories, local sources and the main river (the upper Chattahoochee River). WEAP handles local sources and the main river and tributary sources differently, which is the reason for the distinction in this document. WEAP maintains a streamflow account for river and tributary sources, meaning that the relationship between withdrawals and confluence flows is preserved down the river and through time. Thus, the amount of water in the river at any location is accounted for depending upon withdrawals and return flows along the river. By comparison, a streamflow account is not used for a local supply "other" sources. Rather, water is withdrawn to meet demand site demands but there is no streamflow accounting. In other words, WEAP is not taking account of where water is withdrawn from the stream. Reservoir storage can be included on the river source to carry over surplus flows to future months. Local sources can be defined to supply multiple demand sites, but the demand sites cannot be represented spatially with respect to one another as they can with the river source. Groundwater is defined as a local source with an initial and maximum accessible storage and recharge rate. Monthly withdrawals are controlled by a user specified input called the pumping capacity. The storage available at the end of each month is the beginning of month accessible storage plus any lagged recharge minus the monthly withdrawal due to pumping.

Maximum Number of Study Components

Table 7 summarizes the upper limits of WEAP components for modeling the supplies and demands of a watershed. Experience with the upper Chattahoochee study indicates that these limits do not pose a significant constraint to creating a representative model of the area. Where a region exceeds the supply and demand limits of the program a simple solution is to divide the region into smaller study areas such that each study area is within the capacity of the program. This has the additional advantage allowing greater accuracy in defining the components, making each area easier to analyze and interpret. It also provides greater flexibility in updating and altering the individual areas.

Table 7 Maximum Number of Sub-Basin Components	
60	Years of Monthly Hydrology
1	Main River
6	Tributaries
28	Nodes on Main River or Tributary Node Types: Reservoir, Hydropower, Withdrawal, Confluence, Tributary, Diversion
10	Wastewater Treatment Plants
3	Instream Requirements for Each of Up to 5 Reaches on a River or Tributary
42	Local Supply Sources
99	River or Local Supply Priorities
65	Demand Sites
12	Transmission Links per Demand Site 10 Links to Local Sources 1 Link to Main River 1 Link to Tributary 1 Link to Wastewater Treatment Plant
2	Outflow Links per Wastewater Treatment Plant 1 Link to River or Tributary Node 1 Link to Groundwater Source
3	Return Links Per Demand Site 1 Link to Main River or Tributary 1 Link to Groundwater
4	Demand Data Levels (Sector, Subsector, Enduse, Device) Unlimited Branches at each level
5	Demand Years (Base Year and 4 Future Years)
5	Default Reporting Years (May be changed for individual tables)

MAKING MODIFICATIONS IN WEAP

When making changes to the model of a study area it is of primary importance to be aware that changes made in one part of WEAP often affect other parts. For example, data describing a demand site is located in the SETUP, DEMAND, and DISTRIBUTION programs. Some changes made in one program or screen are automatically transferred throughout WEAP, and others are not. In this section some of the more common and complex modifications are discussed. Modifications may be broadly classified as additions, deletions, and reassignments. Additions refer to adding new demands, demand sites, supply sources, or lengthening the period of analysis. Deletions cover removing demands, demand sites, supply sources, or shortening the period of analysis. Examples of reassignments are redefining a confluence as a tributary, increasing a link capacity or loss rate, and transferring a demand from one demand site to another. An efficient method of implementing changes, is to initiate as many changes as possible in the SETUP program, and then follow up the related details in the other programs.

Additions

A general approach for making additions in WEAP is to name the addition and connect it to related elements in the SETUP program, then quantify it in the DEMAND, DISTRIBUTION, or SUPPLY programs as appropriate.

Demand Site. Adding a demand site begins in the SETUP program under the Configuration menu, demand site screen. Once the new site has been named and described with a brief note, the site will automatically appear on a system network screen under the same menu. The user must then specify the supply sources and any return flow destinations. The next step is taken in the DEMAND program. If the new demand site is replacing an existing demand, the user only needs to substitute the new demand site for the old at the "Device water use rate" level of the branch structure. The new site automatically appears in the list of demand sites to choose from in the DEMAND program. If the new demand site represents an entirely new demand, the user must add the necessary device, end-use, sub-sector, etc. as the case may be. Finally, the monthly variations, loss and reuse rates, and percent return flow, if any, must be specified in the DISTRIBUTION program.

Demand Value. Adding a new demand value to the branch structure requires nothing more than typing in the new addition. If the new demand is entered at the sector, sub-sector, or end use level of the branch structure, the remainder of the branch must be completed by adding the necessary levels down to the lowest or "Device water use rate" level. The new demand must then be assigned to a demand site at the Device water use rate level. The entire operation is contained within the DEMAND program.

Supply Source. Depending on the type of source to be added and the hydrologic method used in the particular study area, the process of adding a source can be very simple or very involved. Adding new sources is more straightforward with the hydrologic fluctuation option than the historical flow data option. Likewise, adding a local source is easier than adding a main river or tributary. Adding a new withdrawal or reservoir node to a river or tributary is discussed under the Reassignment section.

The first step to add a local source regardless of the hydrology is in the Configuration menu of the SETUP program, local sources screen. The type of source must also be specified at this point, be it groundwater, reservoir, or other. If the new source is a main river or tributary, it must be named in the Configuration menu and all nodes subsequently defined, also in the Configuration menu. The new source should then be linked to the appropriate demand sites in the system network screens, having been automatically added to the list of sources.

If historical flows are being used, local reservoir and "other" type sources must be quantified in the data file HISTSUP.DAT outside of WEAP. The location of the new data within the HISTSUP.DAT file must match the position of the new source in the list of local sources under the Configuration menu, e.g. if the new source is first on the local supplies list then the historical data corresponding to that source must also be first in the HISTSUP.DAT file. A groundwater source is fully specified in the Local Supplies menu of the SUPPLY program. Adding a main river or tributary entails creating or adding to the HISTRIV.DAT file.

If hydrologic fluctuations are being used, all local sources as well as tributaries and the main river are quantified in the SUPPLY program under their respective menus.

Return Flow. Adding a return flow from a demand site can be somewhat complicated. If the desired return flow destination is the main river or tributary, the demand site must have a withdrawal link to that source. If the demand site is only linked to local sources, an additional link to the river or tributary must be added to allow returns to the river or tributary. The capacity of the added link should be zero, which will insure that water will not be supplied along the link but still allows returns to take place. A new withdrawal node may have to be added to the river or tributary to serve as the connection to the demand site, or an existing withdrawal node can also be used. For the sake of simplicity, the withdrawal node connected to the demand site with the link capacity of zero can serve as the destination node of the return flow. If the return flow goes to a groundwater source, no special links need be defined. Figure 34 illustrates the necessary links between the demand site and return flow destination.

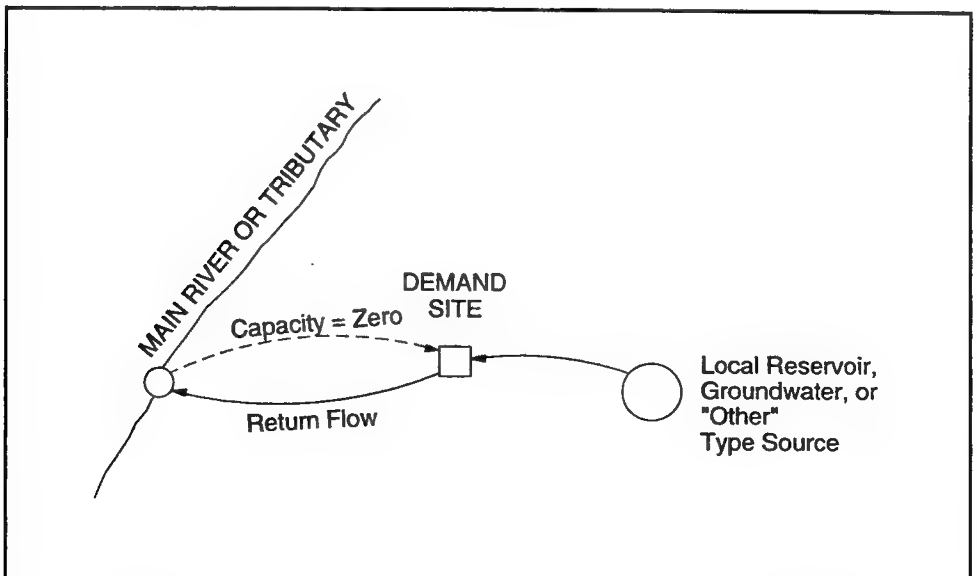


Figure 34: Return Flow to the Main River or Tributary

Extending the Period of Analysis. The period of analysis is specified in the SETUP program on the General Data screen of the Configuration menu, with the last demand data year determining the upper bound on the period. Four different years can be specified as demand data years, and these four years automatically appear in the same positions in the DEMAND program. Changing a year in the SETUP program also automatically changes the same year in the DEMAND program. Future demand projections based on a growth rate or a driver will automatically be extended to the longer period, but future demand values used for interpolation will not be valid unless both the year and demand value are changed together. For example, two demand data years 1990, 1999 may be changed and extended to years 1990, 2009, and 2019 in the SETUP program. In the DEMAND program the year 2009 becomes the interpolated year and the demand value must correspond accordingly. The year 2019, the extended year, takes on the end of period estimate of demand. This is illustrated in the two DEMAND screens below.

If growth rates or drivers are used to project future demands, the period of analysis can be extended simply by changing the demand data years in the Configuration menu of the SETUP program. Before a change in period of analysis:

```
                              Water Use Rate Data

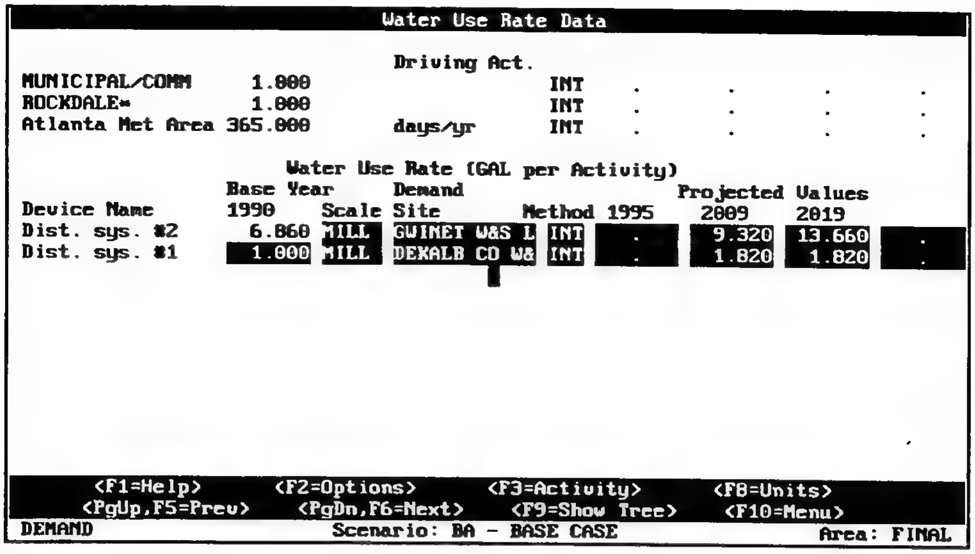
                                  Driving Act.
MUNICIPAL/COMM    1.000                       INT     .      .      .      .
ROCKDALE*         1.000                       INT     .      .      .      .
Atlanta Met Area 365.000          days/yr     INT     .      .      .      .

                       Water Use Rate (GAL per Activity)
                  Base Year       Demand                    Projected Values
Device Name       1990    Scale   Site          Method 1995    2000    2009
Dist. sys. #2     6.860   MILL    GWINET W&S L  INT     .      9.320   13.660    .
Dist. sys. #1     1.000   MILL    DEKALB CO W&  INT     .      1.820   1.820     .




     <F1=Help>        <F2=Options>       <F3=Activity>       <F8=Units>
     <PgUp,F5=Prev>    <PgDn,F6=Next>     <F9=Show Tree>      <F10=Menu>
DEMAND                    Scenario: BA - BASE CASE                  Area: FINAL
```

After a change in the period of analysis:



Deletions

Deleting demand sites, demand values, or supply sources is a simpler process than adding them. When a demand site or supply source is deleted in the SETUP program, it will be automatically removed from the DEMAND, DISTRIBUTION, and SUPPLY programs. However, the user needs to be alert to a few loose ends created by deleting an element of the study.

Demand Site. When deleting a demand site the user should be aware that any demands that have been assigned to that site in the demand branch structure are not automatically deleted. If the demand associated with the deleted demand site is also to be removed, it must be done separately in the DEMAND program. If the associated demand is to remain a part of the study, it must be reassigned to a different demand site.

Demand Value. Deleting a demand value is handled entirely in the DEMAND program. The user should realize that deleting a demand at any level of the branch structure will automatically eliminate the rest of the branch below that level.

Supply Source. Deleting a supply source other than groundwater from the SETUP program requires removing the associated inflow data from the HISTSUP.DAT or HISTRIV.DAT file if historical flows are being used. If the simplified hydrologic fluctuation method is being used, WEAP automatically deletes the flow data from the SUPPLY program. Deleting a groundwater source from the SETUP program is all that is necessary to completely remove it from the study regardless of whether historical flows or hydrologic fluctuations are being used.

Shortening the Period of Analysis. As in extending the period of analysis, changing the demand data years from the Configuration menu of the SETUP program does not require further modifications if all demand projections are based only on growth rates and/or macrodrivers. Where interpolation is used for future projections, the future demand values should be reviewed and adjusted as necessary to correspond with the changed year or years.

Reassignment

Reassignment involves redefining, reclassifying, or reorganizing existing components of the study. It may also include updating or increasing quantities such as demand levels, link capacities, or loss rates. During the initial setup process, the user makes a number of decisions such as which sources will be part of the main river system and which will be handled separately; which demands will be associated with particular demand sites; and which sources will be connected to which demand sites. When it becomes necessary to change the relationships between elements of the study area, the user can save time by understanding all that is required to implement the desired change.

Updating Values. Altering purely quantitative values is accomplished by changing the single value in question. This holds for all values in the demand branch network, link capacities, loss rates, return flow percentages, and data describing reservoirs and groundwater sources. Changing instream requirements, the minimum downstream requirements, and default reporting years is also done by changing just the one value. Exceptions are limited to variables that are defined as percentages that must sum to 100, such as monthly fluctuations of demand, where the sum of the twelve months' percentages must equal 100. Increasing or decreasing one month's percentage requires adjusting the remaining months accordingly. Percentages may also be used this way in the demand branch network.

Redefining Sources. Redefining a source is a combination of adding and deleting two different types of sources. The data that quantifies the source does not have to be changed, it only needs to moved from one screen or part of a file to another. If the river option is involved, it may be necessary to redefine one or more river nodes. For example, if a simple confluence flow is to become a tributary, the river node must be changed from a confluence node to a tributary node. The data that quantifies the flow associated with the tributary must also be moved in HISTRIV.DAT if historical flows are being used, or from a main river confluence screen to the tributary headflow screen in the SUPPLY program. New links to demand sites or links that were previously connected to the supply source must be defined or redefined in the SETUP program, and capacities specified in the DISTRIBUTION program.

Reassigning Demand. Switching a particular demand from one demand site to another only requires changing the demand site at the Device water use rate level of the demand branch structure. A more extensive reorganization of the demand structure relative to demand sites requires careful planning and a good picture of the desired results prior to initiating any actual changes in WEAP.

Redefining a Demand Site. A demand site is defined in several ways, examples being its links to supply sources, the various quantities and types of demand that constitute its bulk demand, and the losses, link capacities, and monthly distribution of annual demand. Adding a link to a supply source in the SETUP program dictates specification of the link capacity, losses, and monthly variations in the DISTRIBUTION program. Deleting a link in the SETUP program requires no further action anywhere else in WEAP. Reorganizing demand associated with a demand site is covered in the previous point; changing the other characteristics involves simply changing the old values to the new values.

CALCULATE AND VIEW RESULTS

Presentations of demand, distribution and supply data, together with comparative analyses of these data, are available from the "Calculate and View Results" of each program menu. Demand results are available from the demand menu and distribution results from the distribution menu. Supply results, including both supply data and comparisons between supply and demand, are available from the supply menu. These results can be displayed in a variety of ways using several options. To illustrate, a number of results screens are described below.

Demand Results

Demand Site by Year, All Sectors. In this report each demand site in the study area is listed together with the demand for the base year and future years. This amount is the aggregate for all sectors - municipal, industrial and agricultural. Thus for Habersham County demand is projected to increase from 9.09 million m^3 in 1990 to 12.76 million m^3 in 1999.

DEMAND RESULTS

WATER DEMAND: DEMAND SITE BY YEAR, ALL SECTORS

(MILLION CUB. METERS)

	1990	1995	1999
HABERSHAM	9.09	10.94	12.76
WHITE	2.52	3.00	3.47
HALL	3.89	4.69	5.49
GAINESVILLE MWS	17.43	22.17	26.88
LUMPKIN	2.66	3.17	3.68
DAWSON	0.01	0.01	0.01
FORSYTH	8.61	10.69	12.75
BUFORD MWS	1.02	1.38	1.67
GWINNETT	0.14	0.14	0.14
GWINET W&S LAKE	67.51	87.08	102.74
GWINNETT CHAT.	11.12	0.33	0.33
ATL/FULTON MWS	0.00	57.60	69.50
DEKALB	0.75	0.75	0.75
DEKALB CO W&S A	109.37	124.00	135.70
FULTON	2.76	2.76	2.76
ROSWELL MWS	0.86	1.13	1.34

<←> <→> <↑> <↓>

<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>

DEMAND Scenario: BA - BASE CASE Area: UCHAT94M

Demand Site by Sector, 1990. For a single year (any base or future year may be selected), the water demand for each demand site is shown by sector - municipal, industrial, agricultural and total.

DEMAND RESULTS				
WATER DEMAND: DEMAND SITE BY SECTOR, 1990 (MILLION CUB. METERS)				
	MUNICIPAL	INDUSTRIA	AGRICULTU	TOTAL
HABERSHAM	5.70	1.05	2.33	9.09
WHITE	1.56	0.17	0.79	2.52
HALL	2.81	0.12	0.95	3.89
GAINESVILLE MWS	15.64	1.79	0.00	17.43
LUMPKIN	1.65	0.22	0.79	2.66
DAWSON	0.00	0.00	0.01	0.01
FORSYTH	6.88	0.74	0.99	8.61
BUFORD MWS	1.02	0.00	0.00	1.02
GWINNETT	0.00	0.00	0.14	0.14
GWINET W&S LAKE	67.51	0.00	0.00	67.51
GWINNETT CHAT.	11.12	0.00	0.00	11.12
ATL/FULTON MWS	0.00	0.00	0.00	0.00
DEKALB	0.00	0.00	0.75	0.75
DEKALB CO W&S A	109.37	0.00	0.00	109.37
FULTON	0.00	0.00	2.76	2.76
ROSWELL MWS	0.86	0.00	0.00	0.86

<←> <→> <↑> <↓> <F6=1991>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
DEMAND Scenario: BA - BASE CASE Area: UCHAT94M

Sector by Year, All Demand Sites. A summary table is also available showing how future demand will change by sector. The years displayed may be selected as an option.

DEMAND RESULTS			
WATER DEMAND: SECTOR BY YEAR, ALL DEMAND SITES (MILLION CUB. METERS)			
	1990	1995	1999
MUNICIPAL/COMM	511.75	597.67	676.89
INDUSTRIAL	447.63	449.09	450.20
AGRICULTURE	11.09	11.09	11.09
TOTAL	970.47	1057.85	1138.18

<←> <→> <↑> <↓> <F5=1998>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
DEMAND Scenario: BA - BASE CASE Area: UCHAT94M

View Data Echo. A Demand Branch Data Report is available from the View Data Echo menu option. This report provides a tree of the four demand branch levels - sector, subsector, enduse, device - for all water users. Each level in the branch structure shows demand amounts (or water use rates) with corresponding units for the base year and specified future years. This tree structure is useful for seeing the connection between all users. Annual demand amounts are computed by multiplying in turn demand, or water use rates, at the lowest level (device water use rate) to the highest (sector). For Habersham County in 1990, for example, the city of Alto has a demand of 323 m^3 per day. As one element of urban use this amounts to 117,895 m^3 per year. This annual amount is aggregated to the subsector (Habersham County) and sector (Municipal/Commercial) level.

```
                          File: DEMAND.ECH                             1 of 6
     AREA: UCHAT94M                                                 Page  1
 SCENARIO: BASE CASE

      ----  D E M A N D   B R A N C H   D A T A   (at Reporting Years) ----
SECTOR
  SUBSECTOR                   ---------- ACTIVITY LEVELS/WATER USE RATE -------
    ENDUSE                      1990      1995      1999   SCALE   VARIABLE/DEMAND SITE
      DEVICE                    ----      ----      ----   -----   --------------------

MUNICIPAL/COMM                 1.000     1.000     1.000
  HABERSHAM COUNTY             1.000     1.000     1.000
    Urban                    365.000   365.000   365.000                days/yr
      Alto              -T     1.000     1.000     1.000                water use/d
                         L   323.000   411.062   498.508                M^3 HABERSHAM
      Baldwin/Demorest--T      1.000     1.000     1.000
                         L     3.678     4.681     5.677   THOUSAND  M^3 HABERSHAM
      Clarksville       -T     1.000     1.000     1.000
                         L     2.571     3.272     3.968   THOUSAND  M^3 HABERSHAM
      Cornelia          -T     1.000     1.000     1.000
                         L     7.339     9.340    11.327   THOUSAND  M^3 HABERSHAM
      Habersham         -T     1.000     1.000     1.000
        <←>         <→>         <↑>         <↓>          <F6=Next>
     <F1=Help>    <F2=Options>    <F7=Text Size>    <F10=Main Menu>
DEMAND                 Scenario: BA - BASE CASE                  Area: UCHAT94M
```

Distribution Results

There is only two reports in the distribution menu that presents results of the physical data. One is in Calculate/View Results and the other the View Data Echo data. In the first - Supply Requirement - distribution losses and reuse which are specified in the distribution program are combined with demand estimates to give a total supply requirement. No cost data was used in the upper Chattahoochee study.

WEAP DISTRIBUTION PROJECTIONS

Table:

- Supply Requirement (annual/monthly)
- Demand Site Costs
- Transmission Link Costs
- Demand Site Return Link Costs

DISTRIBUTION Scenarios: BA, BA Area: UCHAT94M

Supply Requirement. The supply requirement for each demand site for the year 1990 is illustrated below. In the upper Chattahoochee illustration losses and reuse are assumed zero.

WEAP DISTRIBUTION PROJECTIONS
SUPPLY REQUIREMENT: MONTHLY
(Demand + Distribution Losses - Reuse)
1990
(MILLION CUB. METERS)

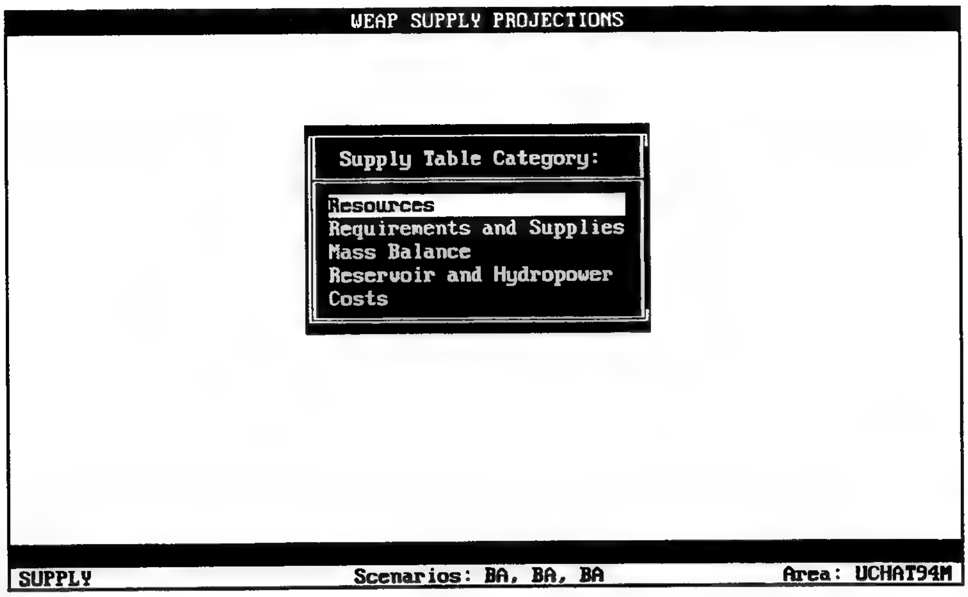
	ANNUAL	JAN	FEB	MAR	APR
HABERSHAM	9.09	0.71	0.68	0.68	0.73
WHITE	2.52	0.21	0.21	0.21	0.21
HALL	3.89	0.32	0.32	0.32	0.32
GAINESVILLE MWS	17.42	1.34	1.33	1.33	1.40
LUMPKIN	2.66	0.22	0.22	0.22	0.22
DAWSON	0.01	0.00	0.00	0.00	0.00
FORSYTH	8.61	0.73	0.62	0.69	0.69
BUFORD MWS	1.02	0.08	0.08	0.08	0.08
GWINNETT	0.14	0.01	0.01	0.01	0.01
GWINET W&S LAKE	67.52	5.27	5.15	5.15	5.42
GWINNETT CHAT.	11.12	0.79	0.70	0.81	0.86
ATL/FULTON MWS	0.00	0.00	0.00	0.00	0.00
DEKALB	0.75	0.06	0.06	0.06	0.06
DEKALB CO W&S A	109.42	8.62	7.61	8.54	8.72

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
DISTRIBUTION Scenarios: BA, BA Area: UCHAT94M

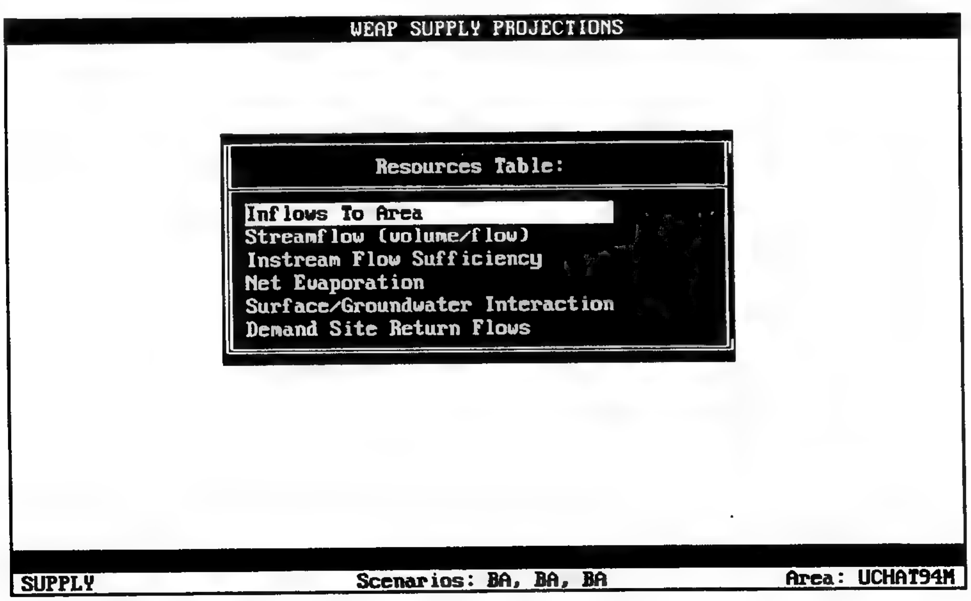
View Data Echo. The View Data Echo report provides input data on the percentage of the annual demand for each month, distribution losses and reuse for each demand site. In the upper Chattahoochee study the losses and reuse is assumed zero.

Supply Results

Supply results are more extensive than either demand or distribution for two reasons: there are a variety of supply sources and the sufficiency of supply is also reported which requires it to be compared with demand. The supply results menu shown below provides the user with five categories of results each of which is illustrated in the screens which follow. Again the options menu (F2) provides the user with a variety of ways to display these data.



Resources. The variety of results available under the category of "resources" are shown in the menu of the Resources Table. These include all the basic sources and losses of water supply.



Inflows to Area. These are the streamflows entered into WEAP using either the Historical Method or Hydrologic Fluctuations. When the Historical Method is used the streamflows are entered in the HISTSUP.DAT and HISTRIV.DAT files. The monthly averages entered (cubic meters per second) are converted to annual volumes (million cubic meters) and displayed in the Inflow to Area report. The units may be changed as desired using the options key (F2).

WEAP SUPPLY PROJECTIONS
INFLOWS TO AREA
(MILLION CUB. METERS)

	1990	1995	1999
LOCAL SOURCES			
Soque Riv 10.5	252.45	159.08	246.90
Turner Cr 0.5	20.74	13.09	20.30
Camp Cr 3.5	5.56	3.49	5.43
Yahoola Cr 5.0	79.22	49.20	86.45
Big Creek	120.73	68.38	98.71
Sweetwtr Cr 16	221.06	165.09	229.72
Lake Allatoona	107.17	107.17	107.17
SW - UNACC'TED	13.40	13.40	13.40
GW - BLUE R/PDM	1.23	1.23	1.23
SWEETWATER CRK			
HEAD FLOW	356.72	265.45	369.66
U.Chattahoochee			
HEAD FLOW	2152.69	1301.34	2145.59

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Streamflow: (Volume/Flow). Unlike the Inflow to Area results which represents input data, the Streamflow: Volume/Flow represents simulated monthly and annual volumes (or flows) on the main river and tributaries. As such they take into account gains and losses along the river or tributary.

WEAP SUPPLY PROJECTIONS
STREAMFLOW: VOLUME
1990
(MILLION CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR	
SWEETWATER CRK						
EAST POINT MWS	343.60	45.12	24.00	109.07	54.80	32
U.Chattahoochee						
LAKE LANIER	2288.06	201.48	130.24	559.92	245.59	179
US SUWANEE CRK	2275.86	200.63	129.50	558.96	244.64	178
SUWANEE CR	2343.35	209.19	134.20	579.64	253.73	186
NORCROSS LOCAL	2510.50	228.41	146.15	620.47	273.76	204
ROSWELL LOCAL	2591.05	238.28	151.82	643.29	284.17	213
DS JOHN'S CREEK	2590.46	238.26	151.81	643.16	284.11	213
HOLCOMB BRDG RD	2474.99	229.19	143.80	634.06	274.90	202
BIG CR	2602.25	244.30	151.70	672.73	290.56	216
ROSWELL RD BRDG	2601.65	244.28	151.68	672.60	290.50	216
WL.CK/BG.JN.WW	2611.29	244.26	152.46	673.16	291.25	217
MORGAN LOCAL	2768.23	262.27	162.48	716.67	309.76	234

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

WEAP SUPPLY PROJECTIONS STREAMFLOW: FLOW 1990 (CMS)	ANNUAL	JAN	FEB	MAR	APR	
SWEETWATER CRK						
EAST POINT MWS	10.88	16.85	9.92	40.72	21.14	12
U.Chattahoochee						
LAKE LANIER	72.21	75.22	53.84	209.05	94.75	67
US SUWANEE CRK	71.83	74.91	53.53	208.69	94.38	66
SUWANEE CR	73.96	78.10	55.47	216.41	97.89	69
NORCROSS LOCAL	79.26	85.28	60.41	231.66	105.62	76
ROSWELL LOCAL	81.81	88.96	62.76	240.18	109.63	79
DS JOHN'S CREEK	81.79	88.96	62.75	240.13	109.61	79
HOLCOMB BRDG RD	78.13	85.57	59.44	236.73	106.06	75
BIG CR	82.15	91.21	62.71	251.17	112.10	80
ROSWELL RD BRDG	82.13	91.20	62.70	251.12	112.08	80
WL.CK/BG.JN.WW	82.44	91.19	63.02	251.33	112.36	81
MORGAN LOCAL	87.41	97.92	67.16	267.58	119.50	87

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Instream Flow Sufficiency. Instream flow requirements may be specified along the main river or tributaries. In this table they are compared with the simulated flow to measure whether or not the simulated flow is adequate to the requirement. This comparison is presented in the screen below for the year and month indicated.

WEAP SUPPLY PROJECTIONS
INSTREAM FLOW SUFFICIENCY
1990
(MILLION CUB. METERS)

Name: U.Chattahoochee, US PEACHTREE CR
Req: WATER QUALITY, wastewater dilut

	JAN	FEB	MAR	APR	MAY	
ACTUAL FLOW	263.34	157.33	744.78	311.82	232.40	166
INSTREAM REQ.	56.89	51.38	56.89	55.05	56.89	55
DEVIATION	206.45	105.95	687.89	256.77	175.51	111

Name: U.Chattahoochee, ATLANTA LOCAL
Req: WATER QUALITY, 7Q10 flow

	JAN	FEB	MAR	APR	MAY	
ACTUAL FLOW	276.82	169.24	757.89	325.00	246.75	181
INSTREAM REQ.	68.27	61.66	68.27	66.06	68.27	66
DEVIATION	208.55	107.58	689.63	258.93	178.48	115

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Net Evaporation. Annual and monthly evaporation volumes are computed for the reservoirs, main river, and tributaries in the watershed for the year selected.

WEAP SUPPLY PROJECTIONS
NET EVAPORATION
1990
(MILLION CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR	
SWEETWATER CRK RESERVOIRS						
U.Chattahoochee RESERVOIRS						
LAKE LANIER	101.25	6.00	8.56	12.72	17.24	26
SWEETWATER CRK REACHES						
EAST POINT MWS	0.07	0.00	0.00	0.02	0.01	0
U.Chattahoochee REACHES						
LAKE LANIER	0.53	0.02	0.01	0.11	0.05	0
US SUWANEE CRK	0.53	0.02	0.01	0.11	0.05	0
SUWANEE CR	0.55	0.02	0.01	0.12	0.05	0
NORCROSS LOCAL	0.58	0.02	0.01	0.12	0.05	0
ROSWELL LOCAL	0.60	0.02	0.02	0.13	0.06	0
DS JOHN'S CREEK	0.60	0.02	0.02	0.13	0.06	0

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Demand Site Return Flows. Demand site return flow volumes, annual and monthly for the year selected, are reported together with the river location where the return occurs. This report provides a summary of all demand site return flows in the system.

WEAP SUPPLY PROJECTIONS
DEMAND SITE RETURN FLOWS
1990
(MILLION CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR
GAINESVILLE MWS					
OUTFLOW TO:					
RIVER					
U.Chattah, LAKE LANIER	8.79	0.68	0.67	0.67	0.71
GWINET W&S LAKE					
OUTFLOW TO:					
RIVER					
U.Cha, MRTA BLVD/WW.RT	50.10	3.91	3.82	3.82	4.02
GWINNETT CHAT.					

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Requirements and Supplies. The menu for this category of reports is shown below and provides presentations of what is required to supply each demand site.

```
                          WEAP SUPPLY PROJECTIONS
                         UNALLOCATED LOCAL SUPPLIES
                                    1990
                           (MILLION CUB. METERS)

                                                                 APR
                    Requirements and Supplies Table:             ---
Soque Riv 10.5                                                 39.40      29
Turner Cr 0.5     Supply Requirement (annual/monthly)           3.11       2
Camp Cr 3.5       Supply Requirement Coverage (annual/monthly)  0.55       0
Yahoola Cr 5.0    Unmet Supply Requirement                     12.92       8
Big Creek         Supply By Source (annual/monthly)            15.70      14
Sweetwtr Cr 16    Unallocated Local Supplies                   34.74      21
Lake Allatoona                                                  4.40       4
SW - UNACC'TED       0.00       0.00       0.00       0.00      0.00       0
GW - BLUE R/PDM      0.00       0.00       0.00       0.00      0.00       0
                    ------     ------     ------     ------    ------     --
TOTAL              749.89      80.36      51.52     197.24    110.82      80


SUPPLY                    Scenarios: BA, BA, BA                Area: UCHAT94M
```

Supply Requirement (Annual/Monthly). Annual supply requirements at each demand site are presented as annual volumes for base and future years. These requirements include distribution losses and reuse. The table is identical to that reported in the Distribution - Calculate and View Results.

```
                          WEAP SUPPLY PROJECTIONS
                         SUPPLY REQUIREMENT: ANNUAL
                 (Demand + Distribution Losses - Reuse)
                           (MILLION CUB. METERS)

                       1990       1995       1999
                       ----       ----       ----
HABERSHAM              9.09      10.93      12.76
WHITE                  2.52       2.99       3.46
HALL                   3.89       4.69       5.48
GAINESVILLE MWS       17.42      22.15      26.86
LUMPKIN                2.66       3.17       3.68
DAWSON                 0.01       0.01       0.01
FORSYTH                8.61      10.69      12.75
BUFORD MWS             1.02       1.38       1.67
GWINNETT               0.14       0.14       0.14
GWINET W&S LAKE       67.52      87.09     102.75
GWINNETT CHAT.        11.12       0.33       0.33
ATL/FULTON MWS         0.00      57.64      69.55
DEKALB                 0.75       0.75       0.75
DEKALB CO W&S A      109.42     124.06     135.77
FULTON                 2.76       2.76       2.76
              <←>         <→>           <T>          <↓>
          <F1=Help>   <F2=Options>  <F7=Text Size>  <F10=Main Menu>
SUPPLY                    Scenarios: BA, BA, BA                Area: UCHAT94M
```

Supply Requirement Coverage. Coverage is the percentage of the supply requirement that is met by the supply source. For example, for the Habersham demand site (Habersham County) the annual supply requirement for 1990 is 9.09 million cubic meters and the total of local supply sources is 6.07 million cubic meters (see the mass balance table). Therefore, 66.7 percent of the requirement is met by local supplies. In this example the requirement is not met because of the permit amount limits the link capacity. So while their is ample water available withdrawal above a certain limit is not permitted by the State.

WEAP SUPPLY PROJECTIONS

SUPPLY REQUIREMENT COVERAGE: ANNUAL
(Demand + Distribution Losses - Reuse)

	1990	1995	1999
HABERSHAM	66.7%	40.7%	39.3%
WHITE	100.0%	53.2%	46.0%
HALL	97.5%	64.3%	56.2%
GAINESVILLE MWS	100.0%	99.1%	51.7%
LUMPKIN	99.6%	52.1%	44.9%
DAWSON	100.0%	16.3%	16.3%
FORSYTH	100.0%	100.0%	63.9%
BUFORD MWS	100.0%	100.0%	59.5%
GWINNETT	100.0%	69.2%	62.4%
GWINET W&S LAKE	100.0%	100.0%	60.5%
GWINNETT CHAT.	100.0%	100.0%	62.7%
ATL/FULTON MWS	N/A	98.7%	51.4%
DEKALB	97.3%	63.9%	56.0%
DEKALB CO W&S A	100.0%	100.0%	60.6%
FULTON	100.0%	69.2%	62.4%
ROSWELL MWS	100.0%	100.0%	100.0%

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Unmet Supply Requirement. The unmet requirement is the volume of annual or monthly supply which is not met by the supply sources. Using the preceding example for Habersham, the difference between annual requirement and supply is 3.025 million cubic meters. The asterisk denotes that the unmet supply is "Due to supply availability and link capacity."

WEAP SUPPLY PROJECTIONS
UNMET SUPPLY REQUIREMENT
1990
(THOUSAND CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR	
HABERSHAM	3025.61	147.86*	173.73*	120.58*	189.52*	235
WHITE	0.00	0.00	0.00	0.00	0.00	0
HALL	96.35	3.30*	27.90*	3.30*	11.35*	3
GAINESVILLE MWS	0.00	0.00	0.00	0.00	0.00	0
LUMPKIN	11.92	0.00	11.92*	0.00	0.00	0
DAWSON	0.00	0.00	0.00	0.00	0.00	0
FORSYTH	0.00	0.00	0.00	0.00	0.00	0
BUFORD MWS	0.00	0.00	0.00	0.00	0.00	0
GWINNETT	0.00	0.00	0.00	0.00	0.00	0
GWINET W&S LAKE	0.00	0.00	0.00	0.00	0.00	0
GWINNETT CHAT.	0.00	0.00	0.00	0.00	0.00	0
ATL/FULTON MWS	0.00	0.00	0.00	0.00	0.00	0
DEKALB	20.45	0.70*	5.88*	0.70*	2.41*	0
DEKALB CO W&S A	0.00	0.00	0.00	0.00	0.00	0
FULTON	0.00	0.00	0.00	0.00	0.00	0

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Supply by Source: Annual/Monthly. This report presents the annual or monthly amount of water that is used from each supply source to meet the requirements of the demand sites. In the case of Habersham County which withdraws from the Soque River, the amount which can be withdrawn is limited by the permitted amount (link capacity) of .044 m^3/s.

WEAP SUPPLY PROJECTIONS
SUPPLY BY SOURCE: ANNUAL
(MILLION CUB. METERS)

	1990	1995	1999
LOCAL SOURCES			
Soque Riv 10.5	1.39	1.39	1.39
Turner Cr 0.5	1.67	1.67	1.67
Camp Cr 3.5	3.34	3.28	3.88
Yahoola Cr 5.0	1.73	1.73	1.73
Big Creek	0.90	1.18	1.41
Sweetwtr Cr 16	0.00	0.00	0.00
Lake Allatoona	56.80	79.11	84.86
SW - UNACC'TED	13.40	13.40	13.40
GW - BLUE R/PDM	13.22	1.23	1.23
SWEETWATER CRK			
EAST POINT MWS	13.05	12.72	12.46
U.Chattahoochee			
LAKE LANIER	95.01	125.56	87.97

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Unallocated Local Supplies. Unallocated local supplies are the difference between what is available as inflow to the area and what is allocated to meet supply requirements. For the Habersham example the annual inflow to the Soque River in 1990 is 252.45 million m^3 and that used by demand sites is 1.39 million m^3. The unallocated supply is 251.07 million m^3.

WEAP SUPPLY PROJECTIONS
UNALLOCATED LOCAL SUPPLIES
1990
(MILLION CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR	
Soque Riv 10.5	251.07	22.93	16.92	57.67	39.40	29
Turner Cr 0.5	19.07	1.75	1.27	4.61	3.11	2
Camp Cr 3.5	2.22	0.18	0.08	0.94	0.55	0
Yahoola Cr 5.0	77.49	6.97	5.34	21.90	12.92	8
Big Creek	127.83	15.15	7.91	38.81	15.70	14
Sweetwtr Cr 16	221.86	28.69	15.55	68.46	34.74	21
Lake Allatoona	50.37	4.68	4.45	4.85	4.40	4
SW - UNACC'TED	0.00	0.00	0.00	0.00	0.00	0
GW - BLUE R/PDM	0.00	0.00	0.00	0.00	0.00	0
TOTAL	749.89	80.36	51.52	197.24	110.82	80

<←> <F1=Help> <→> <F2=Options> <↑> <F7=Text Size> <↓> <F10=Main Menu>

SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Mass Balance. The mass balance menu options shown below are particularly useful for looking at where the water goes in the watershed. Inflow and outflow may be examined at demand sites, local supply sources, river nodes and transmission links.

WEAP SUPPLY PROJECTIONS
UNALLOCATED LOCAL SUPPLIES
1990
(MILLION CUB. METERS)

Mass Balance Table:

- Demand Site Mass Balance
- Local Supply Source Mass Balance
- River Node and Reach Mass Balance
- Transmission Link Mass Balance

					APR	
Soque Riv 10.5					39.40	29
Turner Cr 0.5					3.11	2
Camp Cr 3.5					0.55	0
Yahoola Cr 5.0					12.92	8
Big Creek					15.70	14
Sweetwtr Cr 16					34.74	21
Lake Allatoona	50.37	4.68	4.45	4.85	4.40	4
SW - UNACC'TED	0.00	0.00	0.00	0.00	0.00	0
GW - BLUE R/PDM	0.00	0.00	0.00	0.00	0.00	0
TOTAL	749.89	80.36	51.52	197.24	110.82	80

SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Demand Site Mass Balance. Annual and monthly water volumes supplied to all demand sites from local supply and river sources and outflow to consumption, river or tributary nodes, or groundwater are presented in this report. For Habersham County demand site the local supply sources are the Soque River, Camp Creek and groundwater. All of the water withdrawn is consumed.

WEAP SUPPLY PROJECTIONS
DEMAND SITE MASS BALANCE
1990
(THOUSAND CUB. METERS)

	ANNUAL	JAN	FEB	MAR	APR
HABERSHAM					
INFLOW FROM:					
LOCAL SUPPLY SOURCES					
Soque Riv 10.5	1321.51	112.24	101.38	112.24	108.62
Camp Cr 3.5	3182.82	313.76	283.39	313.76	303.63
GW - BLUE R/PDM	1561.78	132.64	119.81	132.64	128.37
SW - UNACC'TED	0.00	0.00	0.00	0.00	0.00
TOTAL INFLOW	6066.11	558.64	504.58	558.64	540.62
OUTFLOW TO:					
CONSUMPTION	-6066.11	-558.64	-504.58	-558.64	-540.62

(←) (→) (↑) (↓)
(F1=Help) (F2=Options) (F7=Text Size) (F10=Main Menu)
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

River Node and Reach Mass Balance. Along the main river, beginning with any upstream reservoir, a mass balance is presented for each river node. Inflow to the node includes streamflow from the upstream reach, demand site return flow, and gains from groundwater. Outflow includes: demand site withdrawals, net evaporation, losses to groundwater, and streamflow downstream. The screen below is a partial presentation (net evaporation and downstream release are not shown) of the mass balance for Lake Lanier on the upper Chattahoochee River.

WEAP SUPPLY PROJECTIONS
RIVER NODE AND REACH MASS BALANCE
1990
(MILLION CUB. METERS)

Node Name: U.Chattahoochee, LAKE LANIER
Type: RESERVOIR

	ANNUAL	JAN	FEB	MAR	APR
INFLOW FROM:					
UPSTREAM REACH	2152.69	215.72	130.87	585.81	293.40
TOTAL INFLOW	2152.69	215.72	130.87	585.81	293.40
OUTFLOW TO:					
DEMAND SITE					
GAINESVILLE MWS	-18.29	-1.41	-1.30	-1.38	-1.47
FORSYTH	-4.75	-0.38	-0.33	-0.35	-0.38
BUFORD MWS	-1.07	-0.09	-0.08	-0.09	-0.09
GWINET W&S LAKE	-70.89	-5.53	-5.41	-5.41	-5.69

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Transmission Link Mass Balance. A transmission link carries water from the supply source to the demand site. A transmission loss may be specified. A mass balance shows the water withdrawn (inflow), loss (outflow), and amount delivered to the demand site (outflow).

WEAP SUPPLY PROJECTIONS
TRANSMISSION LINK MASS BALANCE
1990
(THOUSAND CUB. METERS)

To: HABERSHAM
From: Soque Riv 10.5

	ANNUAL	JAN	FEB	MAR	APR
INFLOW FROM:					
Soque Riv 10.5	1387.58	117.85	106.44	117.85	114.05
TOTAL INFLOW	1387.58	117.85	106.44	117.85	114.05
OUTFLOW TO:					
TRANSMISSION LOSS	-66.08	-5.61	-5.07	-5.61	-5.43
HABERSHAM	-1321.51	-112.24	-101.38	-112.24	-108.62
TOTAL OUTFLOW	-1387.58	-117.85	-106.44	-117.85	-114.05

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Reservoir and Hydropower. This menu option provides reports on all reservoirs and hydropower facilities in the study area. They show the simulated reservoir storage or elevation monthly for the period of analysis, the storage sufficiency for meeting reservoir storage requirements (operating rule curve), and the amount of hydroelectric power generated during the period of analysis.

```
                          WEAP SUPPLY PROJECTIONS
                      TRANSMISSION LINK MASS BALANCE
                                   1990
                          (THOUSAND CUB. METERS)

                    ┌──────────────────────────────────────────┐ MAR        APR
                    │       Reservoir and Hydropower Table:    │ ---        ---
To:   HABERSHAM     │──────────────────────────────────────────│
From: Soque Riv     │Reservoir Storage (volume/elevation)      │
                    │Reservoir Storage Sufficiency             │
                    │Hydropower Generation (MWH/percent of target)
INFLOW FROM:        └──────────────────────────────────────────┘
 Soque Riv 10.5            1387.58    117.85    106.44    117.85    114.05
                           -------    ------    ------    ------    ------
 TOTAL INFLOW              1387.58    117.85    106.44    117.85    114.05

OUTFLOW TO:
 TRANSMISSION LOSS          -66.08     -5.61     -5.07     -5.61     -5.43
 HABERSHAM                -1321.51   -112.24   -101.38   -112.24   -108.62
                           -------    ------    ------    ------    ------
 TOTAL OUTFLOW            -1387.58   -117.85   -106.44   -117.85   -114.05

SUPPLY                         Scenarios: BA, BA, BA              Area: UCHAT94M
```

Reservoir Storage: Elevation. The monthly reservoir elevation for the year selected is shown in the screen below. There are no reservoirs on the tributary Sweetwater Creek and Lake Lanier is the only reservoir on the upper Chattahoochee.

```
                          WEAP SUPPLY PROJECTIONS
                        RESERVOIR STORAGE: ELEVATION
                                   1990
                                    (M)

                      JAN       FEB       MAR       APR       MAY
                      ---       ---       ---       ---       ---
SWEETWATER CRK

U.Chattahoochee
 LAKE LANIER        326.13    326.09    326.13    326.29    326.44    326




              <←>            <→>            <↑>            <↓>
          <F1=Help>     <F2=Options>    <F7=Text Size>   <F10=Main Menu>
SUPPLY                         Scenarios: BA, BA, BA              Area: UCHAT94M
```

Reservoir Storage Sufficiency. Storage sufficiency is a measure of the actual simulated storage and any monthly reservoir requirements specified by reservoir operating criteria. A plus deviation means that the actual storage is greater than the required storage and therefore is sufficient. Note that in the WEAP program the only operating criteria is the "minimum downstream requirement." Reservoir storage requirements are for comparison purposes only - comparison with simulated storage.

WEAP SUPPLY PROJECTIONS
RESERVOIR STORAGE SUFFICIENCY
1990
(MILLION CUB. METERS)

Name: U.Chattahoochee, LAKE LANIER
Req: RECREATION

	JAN	FEB	MAR	APR	MAY	
ACTUAL STORAGE	2365.58	2359.09	2365.58	2389.15	2412.72	2412
RESERVOIR REQ.	0.00	0.00	0.00	0.00	2183.07	2183
DEVIATION	N/A	N/A	N/A	N/A	229.65	229

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

Hydropower Generation. Annual and monthly generation at hydropower facilities are displayed in this report.

WEAP SUPPLY PROJECTIONS
HYDROPOWER GENERATION
1990
(THOUSAND MWH)

	ANNUAL	JAN	FEB	MAR	APR	
SWEETWATER CRK						
U.Chattahoochee						
LAKE LANIER	226.53	20.71	14.09	60.84	25.22	17
MORGAN FALLS	80.50	8.69	5.38	12.56	10.26	7
TOTAL	307.03	29.39	19.47	73.40	35.48	25

<←> <→> <↑> <↓>
<F1=Help> <F2=Options> <F7=Text Size> <F10=Main Menu>
SUPPLY Scenarios: BA, BA, BA Area: UCHAT94M

View Data Echo. The Supply Data Echo report which may be selected from the Supply menu provides addition supply information not available in the other menu reports. Data Echo reports are only reports on input data, there is no analysis. Some examples are shown below.

Local Supply Sources: Groundwater. This report presents a summary of the basic data input for a groundwater aquifer as a local supply source.

```
File: SUPPLY.ECH                                         2 of 73
SUPPLY DATA ECHO REPORT      AREA: UCHAT94M      11/07/94      09:58:50

              LOCAL SUPPLY SOURCES: GROUNDWATER: GW - BLUE R/PDM

MONTHLY PUMPING CAPACITY (M^3)
------------------------------
STARTUP YEAR (1990):                 1.40 MILLION
MODIFICATION:                        none

MAXIMUM ACCESSIBLE STORAGE (M^3):    10.51 MILLION
INITIAL ACCESSIBLE STORAGE (M^3):    10.51 MILLION
NATURAL ANNUAL RECHARGE (M^3):       1.23 MILLION
LAG TIME (YEARS):                    1

      <←>      <→>      <↑>      <↓>      <F5=Prev>      <F6=Next>
     <F1=Help>     <F2=Options>     <F7=Text Size>     <F10=Main Menu>
SUPPLY                 Scenario: BA - BASE CASE              Area: UCHAT94M
```

Local Supply Sources: Other. This is a convenient report that presents by year and month the streamflow values input using the historical method. Similar data is presented for river nodes and when the hydrologic fluctuation method is used.

```
File: SUPPLY.ECH                                         3 of 73
SUPPLY DATA ECHO REPORT      AREA: UCHAT94M      11/07/94      09:58:50

                 LOCAL SUPPLY SOURCES: OTHER: Soque Riv 10.5

MONTHLY SUPPLY (CMS) (HISTORICAL DATA METHOD)
```

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	
1990	8.606	7.030	21.577	15.245	11.190	8.040	5.410	3
1991	2.659	7.360	4.820	4.908	4.449	5.783	2.852	2
1992	11.209	14.152	8.383	7.250	5.695	4.543	3.809	4
1993	7.921	11.928	10.637	15.641	11.099	7.510	5.120	3
1994	9.116	11.152	10.504	12.243	15.616	7.949	10.062	8
1995	4.604	9.414	5.469	5.171	4.775	3.475	5.117	5
1996	3.982	3.866	4.664	3.339	2.945	2.062	1.509	1
1997	8.173	9.404	11.546	9.162	6.162	5.095	3.973	3
1998	7.403	5.151	4.075	6.514	3.376	2.311	2.693	2
1999	5.670	5.641	8.533	6.667	5.995	11.385	10.578	6

```
      <←>      <→>      <↑>      <↓>      <F5=Prev>      <F6=Next>
     <F1=Help>     <F2=Options>     <F7=Text Size>     <F10=Main Menu>
SUPPLY                 Scenario: BA - BASE CASE              Area: UCHAT94M
```

Reservoir. A summary of the reservoir volume-area-elevation data is shown in this report.

```
                              File: SUPPLY.ECH                      28 of 73
SUPPLY DATA ECHO REPORT      AREA: UCHAT94M       11/07/94       09:58:50

                    U.Chattahoochee: RESERVOIR: LAKE LANIER

                     PHYSICAL DATA: STARTUP YEAR (1990)


TOTAL STORAGE (M^3):                    3151.640 MILLION
INITIAL STORAGE (M^3):                  2365.580 MILLION

V-S-E FUNCTION

VOLUME (M^3)       SURFACE AREA (M^2)       ELEVATION (M)
SCALE: MILLION      SCALE: MILLION     SCALE:

   3151.640             190.933              330.710
   2412.717             155.969              326.441
   2273.275             149.789              325.526
   2130.645             143.882              324.612
   1926.521             134.505              323.088
   1720.587             125.541              321.564
      <←>       <→>       <↑>       <↓>      <F5=Prev>      <F6=Next>
      <F1=Help>    <F2=Options>    <F7=Text Size>     <F10=Main Menu>
 SUPPLY                       Scenario: BA - BASE CASE             Area: UCHAT94M
```

Evaporation and Groundwater Interaction. The evaporation and groundwater interaction data is summarized in this report. For the upper Chattahoochee River only evaporation data was input.

```
                              File: SUPPLY.ECH                      44 of 73
SUPPLY DATA ECHO REPORT      AREA: UCHAT94M       11/07/94       09:58:50

          U.Chattahoochee: EVAPORATION AND GROUNDWATER INTERACTION:

                        LAKE LANIER TO US SUWANEE CRK

SURFACE EVAPORATION (% OF RIVER FLOW)

Jan            0.01
Feb            0.01
Mar            0.02
Apr            0.02
May            0.04
Jun            0.04
Jul            0.04
Aug            0.04
Sep            0.02
Oct            0.02
Nov            0.01
Dec            0.01

      <←>       <→>       <↑>       <↓>      <F5=Prev>      <F6=Next>
      <F1=Help>    <F2=Options>    <F7=Text Size>     <F10=Main Menu>
 SUPPLY                       Scenario: BA - BASE CASE             Area: UCHAT94M
```

Instream Requirements. Instream flow requirements vary from reach to reach along the main river. In this data echo report these requirements are presented by month for each purpose.

```
                                 File: SUPPLY.ECH                     71 of 73
SUPPLY DATA ECHO REPORT       AREA: UCHAT94M       11/07/94       09:58:50

                        U.Chattahoochee: INSTREAM REQUIREMENTS:

                             ATLANTA LOCAL TO US PEACHTREE CR

PURPOSE: WATER QUALITY
NOTE: 7Q10 flow
SCALE: (CMS)
----------------
Jan              25.488
Feb              25.488
Mar              25.488
Apr              25.488
May              25.488
Jun              25.488
Jul              25.488
Aug              25.488
Sep              25.488
Oct              25.488
Nov              25.488
        <←>        <→>        <↑>        <↓>        <F5=Prev>        <F6=Next>
       <F1=Help>      <F2=Options>      <F7=Text Size>      <F10=Main Menu>
 SUPPLY                        Scenario: BA - BASE CASE                 Area: UCHAT94M
```

ANALYSIS AND INTERPRETATION

Returning to the Study Objectives

The WEAP model is rich in technical detail, more detail in fact than is required to answer most study questions. Some of this detail is illustrated in the preceding sections of this report but, even so, the variety of options and forms of display are numerous. The model is a source of technical information that allows the user to address different questions as they arise over time. When analyzing and interpreting this information it is important to focus on the objectives of the study and to select only that information which is relevant to those objectives - what are the questions that need to be answered? What are the reasons for the study? What supply and demand conditions are assumed for the model?

The principal objective of this study as it relates to the upper Chattahoochee watershed is to present observations on the water resources and water use of the basin under present and future conditions. These observations were developed through creating and working with the WEAP model and through analysis and interpretation of the study results. A ten-year hydrology, 1980 to 1989, was assumed for all surface water sources in the watershed and the demand was assumed to grow from present usage to future amounts as projected by water users in the basin.

Observations on the Upper Chattahoochee Watershed

Different Hydrologic Sequences. The various reservoir storage levels that result from different hydrologic sequences show the long-term effects of a single wet or dry year on Lake Lanier. Different arrangements of the same hydrologic years will result in different storage, even though the sum of the inputs may be the same. The hydrology is obviously a critical element in the supply-demand comparison, and the result of the comparison is quite sensitive to the sequence of hydrologic years selected.

Local Supplies. An analysis of local supplies on an annual basis suggests that, within the basin, there are additional quantities of water to meet local needs, even under drought conditions. This water exceeds the water withdrawn from the unaccounted surface water supply source, suggesting that it could be used to meet unpermitted demand. Review of these local supplies on a monthly basis shows that water is available throughout the year, with more available during the wetter months.

Lake Sidney Lanier and the Upper Chattahoochee River. Lake Lanier provides a significant amount of storage for meeting a variety of purposes within the upper Chattahoochee watershed and downstream. The amount of storage available for water supply withdrawal both from the reservoir and the river depends upon the releases to the Chattahoochee for hydroelectric power and other purposes. If minimum downstream requirements at Fairburn gage are set low, for example, at the 7Q10 flow, then more water is available to meet water supply demand. If the requirements are high, for example, at the average period of record level, then shortages in supply will occur.

Withdrawal Permits. Within the next decade, several water supply facilities will need an increase in their water supply withdrawal permits to keep pace with demand projections. Under normal hydrologic conditions, it appears that increasing withdrawals for these systems will not adversely affect competing systems. Under drought conditions the effects of increased permits will have to be assessed using the larger permit amounts in the WEAP model.

Instream Flow Requirements. The minimum downstream requirement at Fairburn gage is the dominant instream demand in the WEAP model. If this instream requirement is met, all other instream requirements upstream to Lake Lanier will also be met in almost all years. Relaxing the minimum flow requirements near Atlanta or just upstream of Peachtree Creek will not free up additional water for withdrawal unless it is coordinated with the Fairburn requirement.

Conclusions from the WEAP Application

The WEAP model of the upper Chattahoochee River Basin provides a comprehensive and integrated picture of the principal water supplies and demands of the region. This picture includes,

. the connection between river and reservoir operations and the water demand of the cities, counties and industries in the basin.

. a comparison of instream requirements for water quality, recreation and fish and wildlife with the demand for municipal/commercial, industrial and agricultural water supply.

. an accounting of all principal water users including their supply sources, permitted withdrawal, and discharges.

. an accounting of all principal surface and groundwater supplies including reservoirs and water transfers.

. an accounting of losses and water reuse in the system including transmission losses, demand site losses, infiltration to groundwater, and river/reservoir evaporation.

. forecasts of future demand for water and the adequacy of available supplies under different hydrologic conditions.

. identification of permitted withdrawals and the adequacy of the permit amounts to meet future demand.

. identification of underutilized sources of water and their availability for transfer to meet future needs.

. the sensitivity of the water system to river flow, reservoir storage, permit requirements and future demand.

Examining this picture from an agency perspective finds the Corps of Engineers responsible for the operation of Lake Sidney Lanier and the Chattahoochee River in the larger context of management of the A-C-F system; the State of Georgia is responsible, through the Environmental Protection Division, for the permitting of withdrawals and minimum streamflow requirements for water quality; the Atlanta Regional Commission has responsibility for preparing plans for water supply and wastewater management in the region; and the U. S. Geological Survey through its water supply and water use programs collects, disseminates and analyzes supply and use data. All of these responsibilities have to do with the same water resource. Using a comprehensive data set compiled through the cooperation of each agency, WEAP models the interrelationships between supply and demand and provides a transparent simulation tool for better water management.

REFERENCES

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Georgia Department of Natural Resources, Environmental Protection Division, 1984, Water Availability & Use, Chattahoochee River Basin, Georgia

Gulf Engineers & Consultants, Inc., 1991. Comprehensive Study of the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins, Summary of the Study Issues Presented at the Public Meetings, 19 July - 26 August 1991, Baton Rouge, Louisiana

Hayes, Richard J., Katherine A. Popko and William K. Johnson, Guide Manual for Preparation of Water Balances, November 1980

Tellus Institute, 1993. WEAP, A Computerized Water Evaluation and Planning System, Boston, Massachusetts

U. S. Army Corps of Engineers, Mobile District, 1989. Apalachicola-Chattahoochee-Flint Basin Water Control Plan, Mobile, Alabama

U. S. Army Corps of Engineers, Mobile District, 1985. Mileage Tables with Drainage Areas, Chattahoochee River, Mobile, Alabama

U. S. Army Corps of Engineers, Mobile District, 1991. Comprehensive Study of the ACT and ACF River Basins, Draft Plan of Study, Comprehensive Study Technical Coordination Group, Mobile, Alabama

U. S. Army Corps of Engineers, Mobile District, 1991. Apalachicola Basin Reservoir Regulation Manual, Appendix B: Buford Dam (Lake Sidney Lanier), Chattahoochee River, Georgia, Mobile, Alabama

U. S. Army Corps of Engineers, Mobile District, 1991. Rainfall, Evaporation, Inflow, and Withdrawal Monthly Data for Lake Lanier, 1957 to 1989, ASCII data and Fortran program files from Norman Karr, Mobile, Alabama, files

U. S. Geological Survey, 1988. Hydrologic Unit Map - 1974, State of Georgia, 1970 edition, Reston, Virginia

U. S. Geological Survey, 1990. Groundwater Atlas of the United States, Segment 6, Alabama, Florida, Georgia, South Carolina, Hydrologic Investigations Atlas 730-G by James A. Miller.

U. S. Geological Survey, Water Resources Division, 1991. Historical Monthly Data for USGS Streamflow Gages in the ACF Basin, 1980 to 1989, supplied in Lotus 123 data files from Norman Karr, US Army Corps of Engineers, Mobile District, Mobile, Alabama

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APPENDICES

APPENDIX A

DATA SOURCES

LAKE LANIER EVAPORATION RATES

Norman Karr, Mobile COE, 1/27/93.

INFLOW TO LAKE LANIER

Norman Karr, Mobile COE, fax 1/28/93. 1980-1989 years, Adjusted Inflow + Lake Rain = input to HISTRIV.DAT for headflow. The term "adjusted" refers to inflow before evaporation, withdrawals, and precipitation have taken place.

LINK CAPACITIES FOR WITHDRAWING WATER SUPPLY FACILITIES

Link capacities are equal to permitted monthly average withdrawal amounts.

a. Link capacity for Atlanta, City of (Atl. MWS) to Chat.- State of Georgia, EPD, 22 Jan 1993.

b. Link capacity for Atlanta-Fulton Plant to Chat.- State of Georgia EPD, 22 Jan, 1993.

c. Link capacity for City of Buford to Lake Lanier- State of Georgia, EPD, 22 Jan 1993.

d. Link capacity for DeKalb County to Chat.- State of Georgia, EPD, 22 Jan 1993.
NOTE The permitted amount exceeds the plant capacity (140 Mgd vs. 121 Mgd). Plant capacity is given in ARC's Regional Water Plan (1991), pg. 22. As Pat Stevens maintains that physical obstacles are easily and willingly overcome in the face of a shortage, I have chosen the higher, legally permitted amount for the link capacity.

e. Link capacity for Gwinnet County to Chat.- ARC recommends a permitted level of 12 Mgd for operation under emergency conditions, so it must be at least that for 1990-1991. Regional Water Supply Plan, 1991, pg. 43, rec'd 22 Feb 1993.

f. Link capacity for Cobb-Marietta Water Authority to Chat.- State of Georgia, EPD, 22 Jan 1993.
NOTE The permitted amount exceeds the plant capacity (58 Mgd vs. 48 Mgd). Plant capacity is given in ARC's Regional Water Plan (1991), pg. 22. I assume that when demand increases to the point of exceeding the plant's capacity, the capacity will be expanded (see note on DeKalb Co.).

g. Link capacity for Georgia Power to Chat.- State of Georgia, EPD, 22 Jan 1993.

h. Link capacity for City of Gainesville to Lake Lanier- State of Georgia, EPD, 22 Jan 1993.

i. Link capacity for Gwinnett Co. W&S Auth. to Lake Lanier- State of Georgia, EPD, 22 Jan 1993.

j. Link capacity for White County W&S Auth. to Turner Creek- State of Georgia, EPD, 22 Jan 1993.

k. Link capacity for Habersham County to Camp Creek- State of Georgia, EPD, 22 Jan 1993, City of Cornelia plus City of Cleveland.

l. Link capacity for Habersham County to Soque River- State of Georgia, EPD, 22 Jan 1993, City of Clarkesville.

m. Link capacity for Lumpkin County to Yahoola Creek- State of Georgia, EPD, 22 Jan 1993, City of Dahlonega, old and new plants.

n. Link capacity for City of Roswell to Chat.- State of Georgia, EPD, 22 Jan 1993. *NOTE* Roswell withdraws from Big Creek in actuality but has been placed on the Chat. downstream of Big Creek's confluence flow for simplicity's sake. The effects of varying demands can be clearly examined without having to define Big Creek as a tributary.

o. Link capacity for Cobb County to Sweetwater Creek- State of Georgia, EPD, 22 Jan 1993, Austell Box Board Company and Sweetwater Paper Company.

p. Link capacity for Cobb-Marietta to Lake Allatoona- David Vaughn of Georgia EPD provided the figure of 78 Mgd monthly average by phone on 11 Feb 1993.

LINK CAPACITIES FOR WASTEWATER TREATMENT PLANTS

Link capacities reflect permitted maximum discharge amounts. Some plants show increased capacities during the period of analysis. This was necessary to allow the plants to meet the increased projected demand without withdrawing water from the Chattahoochee on what is intended to be only the return flow link, not a supply link. The years vary when link capacities are increased, roughly corresponding to the year when the original capacity becomes too small.

a. Link capacity for R.M. Clayton WW- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD.

b. Link capacity for R.L. Sutton WW- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD.

c. Link capacity for John's, & Crooked WW- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD.

d. Link capacity for Big Creek WW- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD.1

e. Link capacity for South River, & Entrenchment Creek WW plants- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD. Entrenchment Creek is believed to be included in this figure, although the EPD Printout did show it specifically.

f. Link capacity for Utoy Creek WW plant- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD. The plant exceeds its permit in 1990.

g. Link capacity for Sweetwater WW plant- EPD PCS Municipal Info. Printout, 16 Feb 1993. Supplied by David Vaughn, Georgia DNR, EPD. The Sweetwater plant is also known as Douglasville (Sweetwater).

h. Link capacity for Camp Creek WW plant- The plant is already operating in excess of its permit in 1990, so I increased the link capacity in 1991 (to 35 cfs) enough to allow correctly modeled operations until 2009.

BASELINE DEMAND AND DEMAND PROJECTION FIGURES

NOTE Slight discrepancies from ARC's numbers are due to a linear interpolation adjustment to accommodate WEAP's planning horizon.

a. Demand for Cobb County- 1990 **Municipal/Commercial** demand is taken from EPD Plant Production Printout, received 16 Feb 1993 from David Vaughn, Georgia EPD. **M/C** demand for Cobb County is met by withdrawals from both Lake Allatoona and the Chat. Projected total demand and future percentages met by the Allatoona and Chattahoochee plants come from the ARC Water Supply Plan, 1991 version, pg. 37, 22 Jan 1993. These withdrawals are also used to meet 1990 and future demands in Cherokee Co., Douglas Co., Paulding Co., Woodstock, and Mountain Park. Demands for Douglas and Paulding Co.'s have been subtracted from Cobb's demand quantities and appear in the demand branch structure under the **Municipal/Commercial** sector for Douglas and Paulding Co.'s respectively. However, they are respectively tied back to the Cobb-Chattahoochee and Cobb-Allatoona withdrawals by specifying these demand sites at the water use level of the demand branch structure. Demands from Cherokee, Woodstock, and Mountain Park fall under the category of "Outside study area" and appear in Cobb County's demand branch.

Demands in the **Agricultural** sector are taken from Water Availability and Use, Chattahoochee River Basin, Dept. of Natural Resources EPD, pg. 79. Demands in the **Industrial** category (under **Paper**) are taken from the reports to Georgia EPD, copies provided by David Vaughn, 16 Feb 1993. The reports from Austell Box Board show a constant water use level at 936,000 gpd over 1990-1992, so a growth rate of 0 was assigned to it. Sweetwater Paper Board's 1990 demand is the average of the monthly averages for 1990. Demand in 1991 and 1992 stays fairly constant averaging around 566,00 gpd, so I entered this value as the 1995 demand with no further projected increase. Agricultural and industrial demands are met by "local sources" linked to the separate Cobb distribution system.

b. Demand for Clayton County- ARC Water Supply Plan, 1991 version, pg. 36. 22 Jan 1993. 1990 and 1999 come from ARC WSP. A percentage of Clayton Co.'s demand is met by buying water from Atlanta MWS, which is reflected in the branch structure for Clayton Co.

Municipal/Commercial sector. The remaining percentage of Clayton's demands are met through sources outside of the study area (Little Cotton Indian, Cotton Indian Creek, Shoal Creek, and Flint River), and do not appear in the branch structure (ARC Water Supply Plan, 1991).

c. <u>Demand for East Point MWS</u>- All demand falls under the **Municipal/Commercial** category; 1990 demand comes for Plant Production Summary 1/26/1993, Georgia DNR, EPD 2/16/1993. Demand projections for 1999 are from ARC Water Supply Plan, 1991 version, pg. 42. 22 Jan 1993. East Point actually withdraws from Sweetwater Creek, but because Sweetwater flows are added to the Chat. as a confluence point, the withdrawals for East Point are subtracted from the Chat. downstream of the confluence point.

d. <u>Demand for Douglas County</u>- 1990 **Municipal/Commercial** demand figures are taken from ARC Water Supply Plan, 1991 version, pg. 39. 22 Jan 1993. The Douglas **M/C** demand was assigned to Cobb-Chattahoochee instead of Cobb-Allatoona although the ARC plan doesn't distinguish on this point. It has to be one or the other, and this seems to make more sense geographically (closer to Chattahoochee than to Allatoona). **Agricultural** demand numbers come from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 79. The EPD report does not list any industrial demands for Douglas County, so none are included in the model. Projections for Douglas County are from ARC' Regional Water Supply Plan, 1991, pg. 39.

e. <u>Demand for Paulding County</u>- 1990 **Municipal/Commercial** demand values come from ARC Regional Water Supply Plan, 1991 version, pg. 37. 22 Jan 1993. Projections for Paulding's **M/C** demand also come from the ARC Regional Water Supply Plan, 1991 version, pg. 37. This demand is assigned to Cobb-Allatoona, which is not specified in the ARC plan. I had to pick one or the other, and chose Allatoona because Paulding is closer to Lake Allatoona than to the Chattahoochee, and is closer to Allatoona than the other recipient of water transfer from Cobb, Douglas Co. I also wanted to split the transferred water between the two systems instead of having one or the other supply all the water for transfer. **Industrial** and **Agricultural** demands are taken from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 77 and 79. Projections are based on the percent growth in water use for Paulding Co., taken from the ARC document, pg. 33. See item **g.** (White County) of this section for the equation used to calculate % growth.

f. <u>Demand for Habersham County</u>- **Industrial**, and **Agricultural** demand numbers come from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD. Page numbers are 76 and 79 respectively. **Municipal/Commercial** 1990 urban demand for Baldwin/Demorest, Cornelia, and Clarkesville come from Plant Production Summary 1/26/1993 from David Vaughn, Georgia Dept. of Natural Resources, EPD, received 2/16/1993. The remaining 1990 **Municipal/Commercial** demands for Habersham County are from the Water Availability and Use, Chattahoochee River Basin, pg. 70. Demand projections for these towns and the rural demand as well are based on an average of ARC's projected growth rates for counties surrounding the Atlanta Met. Area, specifically Gwinnett, Rockdale, Forsyth, Paulding, and Douglas. These counties were used because they are thought to have land use patterns most similar to the counties for which projections have not been done. The result was **4.94%** per year, equation for each county's growth rate is given under **g.** (White County).

g. Demand for White County- **Industrial**, and **Agricultural** demand quantities are taken from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 76 and 79. **Municipal/Commercial** demand for Helen comes from the same source, pg. 74. **Municipal/Commercial** 1990 urban demand for Cleveland comes from Plant Production Summary 1/26/1993 from David Vaughn, Georgia Dept. of Natural Resources, EPD, received 2/16/1993. Demand projections for Cleveland are based on the average percent growth for Forsyth, Paulding, Douglas, Gwinnett, and Rockdale Counties, as projected by ARC's Regional Water Supply Plan, 1991, pg. 33. Percent annual growth is given by the equation (Demand yr 2010/Demand yr 1990)$^{1/20}$ - 1 = % growth/yr. Average % growth = **4.94%**, and was used for White County's urban and rural demand projections.

h. Demand for Lumpkin County- **Industrial**, and **Agricultural** demand levels are taken from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 77 and 79. **Municipal/Commercial** 1990 urban demand for Dahlonega comes from Plant Production Summary 1/26/1993 for Dahlonega plants 1 & 2, provided by David Vaughn, Georgia Dept. of Natural Resources, EPD, received 2/16/1993. Demand projections are based on the average percent growth for Forsyth, Paulding, Douglas, Gwinnett, and Rockdale Counties, as projected by ARC's Regional Water Supply Plan, 1991, pg. 33. Percent annual growth is given by the equation (Demand yr 2010/Demand yr 1990)$^{1/20}$ - 1 = % growth/yr. Average % growth = **4.94%**, which is used for Dahlonega.

i. Demand for Hall County- All categories except **Municipal/Commercial**, urban, 1990 demand for Gainesville from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 71, 76, and 79. Gainesville 1990 **M/C** demand comes from Plant Production Summary 1/26/1993 provided by David Vaughn, Georgia DNR, EPD, received 2/16/1993. Demand projections are based on the same growth rate used for White, Lumpkin, et al.

Two golf courses appear under Hall Co.'s demand branch, both connected to Lake Lanier through Gainesville MWS. These courses are in actuality independent of Gainesville MWS, but are lumped into Gainesville MWS because it saves defining an additional node on Lake Lanier. The golf course demand is low in relation to Gainesville, and is not projected to increase, because golf courses don't usually expand like cities. 1990 demand for both courses is the average of the peak 5 month withdrawals for 1990, as reported to Georgia's EPD, rec'd here 16 Feb 1993.

j. Demand for Forsyth County- All categories except **Municipal/Commercial** urban 1990 demand for Cumming come from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pgs. 70, 75, and 79. Cumming 1990 **M/C** demand comes from Plant Production Summary 1/26/1993 provided by David Vaughn, Georgia DNR, EPD, received 2/16/1993. Demand projections for urban, rural and industry are based on the percent growth rate calculated from ARC's projections found in the Regional Water Supply Plan, 1991 version, pg. 33. Equation is given above under item **g.**

k. Demand for Dawson County- Demand for **Agriculture** is taken from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pg. 79. No other information on Dawson is in this source, or in WEAP. Agricultural demand is not projected to increase.

l. Demand for Gwinnett County- 1990 demand for **M/C**-Buford and Gwinnet-Lanier are from Plant Production Summary 1/16/1993 provided by David Vaughn, Georgia DNR, EPD 16 Feb 1993. Transfers from Gwinnet-Lanier shown in the ARC Water Supply Plan, 1991 version, to Conyers are subtracted from the EPD production total before being entered into WEAP. The Gwinnett-Lanier withdrawal for the City of Conyers in Rockdale County shows up in the model under a separate demand **M/C** subsector named for Rockdale County. Demand projections for 1999 for **Municipal/Commercial** come from ARC Atlanta Regional Water Supply Plan, 1991 version, pg. 40. 22 Jan 1993. The **M/C** demand is broken down into a separate distribution system for Buford, out-of-Gwinnett County deliveries to Loganville, and demand within Gwinnett County. Demand for **Agriculture** is taken from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pg. 79.

m. Demand for DeKalb County- Demand projections for 1999 for **Municipal/Commercial** comes from ARC Atlanta Regional Water Supply Plan, 1991 version, pg. 38. 22 Jan 1993. The 1990 demand for DeKalb MWS is based on the Plant Production Summary 1/26/1993, provided by David Vaughn, Georgia DNR, EPD 2/16/1993. The transfer from DeKalb MWS to the City of Conyers in Rockdale County shown in the ARC Water Supply Report is subtracted from the EPD Report 1990 production total before entering the 1990 demand into WEAP. The same procedure was followed for Henry County as well. The demand from Conyers and Henry County for 1990 and 1999 that are supplied by the DeKalb Municipal Water System are listed under Rockdale and Henry Counties respectively, but are tied back to the DeKalb system at the "water use" level of the demand branch structure. Demand levels (1990-1999) for **Agriculture** come from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pg. 79.

n. Demand for Fulton County- **Municipal/Commercial** demand projections are all taken from ARC Atlanta Water Supply Plan, 1991 version, pg. 42, line entitled "TOTAL Atlanta/Fulton System Demand", rec'd 22 Jan 1993. The **M/C** demand is broken down by distribution system, including Roswell, East Point (see above) and the two Chattahoochee withdrawal points. 1990 demand for Roswell, East Point, Atlanta/Fulton, and Atlanta-Chattahoochee all come from Plant Production Summary 1/26/1993 provided by David Vaughn, Georgia DNR, EPD 16 Feb 1993. Water that is transferred from Fulton County systems to Clayton County (as indicated in the ARC Water Supply Plan, pg. 42) has been subtracted from the EPD report's production total before being entered into WEAP as the 1990 demand. Also, a loss of 5% (5.9 Mgd) was subtracted as well, so that demand = 1990 production - transfer to Clayton Co - transfer to Fayette Co - 5% loss. Demand projections for 1999 also have the amount of planned transfers to Clayton and Fayette Counties subtracted and entered under the destination of the transfer. Any additional transfers have been left included in the Atlanta Met Area demand because the destinations are not included in the model. The following is a sample calculation.

(EPD 1990 Prod. Total for site1 - ARC Report Transfer from site1 - 5% loss = 1990 WEAP Demand for sys.1)
(ARC Report Transfer from site1 to site2) = (1990 WEAP demand for site2)

The amount of the transfer appears as demand under Clayton County, tied back to the appropriate distribution system. Losses for Atlanta MWS are subtracted from the entered demand since WEAP adds them back. See **LOSS RATES** for a brief explanation of Atlanta MWS loss rate. **Agriculture** demand comes from Water Availability and Use, Chattahoochee River Basin, Georgia Dept. of Natural Resources, EPD, pg. 79.

Demand for the Horseshoe Tattersall Golf Club is based on reports from the Club to Georgia's EPD. Because golf course irrigation most often experiences very seasonal peaks and the demand in WEAP is tied to the monthly variations of Roswell MWS, I used the average of only May-Sep 1990 withdrawals instead of the entire year's, to compensate for the lower than actual peaks caused by using Roswell's monthly variations with the annual irrigation average. I used Roswell as Horseshoe's demand site because both withdraw from the Chattahoochee.

o. Demand for Rockdale County- Demand for all years for the **Municipal/Commercial** sector is taken from ARC Atlanta Regional Water Supply Plan, 1991 version, pg. 41. All of Rockdale's demands that affect the study area fall under the **Municipal/Commercial** sector and are tied to two distribution systems outside of Rockdale County.

p. Demand for Industrial-Power- Demand for all years for the **Municipal/Commercial** sector is taken from ARC Atlanta Regional Water Supply Plan, 1991 version, pg. 38. The page number is important because page 33 lists slightly different demand values. Henry County demand is tied back to DeKalb MWS.

q. Demand for Fayette County- Demand for all years for the **Municipal/Commercial** sector is taken from ARC Atlanta Regional Water Supply Plan, 1991 version, pg. 42. The demand is tied back to Atlanta MWS.

r. Demand for Industrial-Power- 1990 demand levels are equal to the average of 1990 withdrawals for each plant. The monthly average withdrawals come from Georgia Power's reports submitted to Georgia DNR, EPD, provided to us by David Vaughn, Georgia Dept. of Natural Resources, EPD, 16 Feb 1993. Demand projects are not available.

WASTEWATER RETURN FLOWS

a. Return flow for R.L. Sutton WW- 1990 base year amount is taken directly from USGS data, faxed from Julia Fanning, received 2 March 1993.

b. Return flow for R.M. Clayton WW- 1990 base year amount is taken directly from USGS data, faxed from Julia Fanning, received 2 March 1993.

c. Return flow for S.River/Entrenchment Creek WW Plants- 1990 base year amount for S. River taken directly from USGS data, faxed from Julia Fanning, received 2 March 1993. It appears that Entrenchment Creek flows are already included in the amount listed for S. River. Georgia DNR, EPD doesn't list a separate discharge permit for Entrenchment Creek either, so it looks like this is in fact the case.

d. Return flow for Big Creek WW- 1990 base year amount is taken directly from USGS data, faxed from Julia Fanning, received 2 March 1993.

e. Return flow for Camp Creek WW- 1990 base year amount is taken directly from USGS data, faxed from Julia Fanning, received 2 March, 1993.

f. Return flow for Sweetwater Creek WW- 1990 base year amount added 3/11/1993, faxed from Julia Fanning, received 10 March 1993.

g. Return flow for Crooked Creek WW- 1990 base year amount taken from USGS data faxed from Julia Fanning, received 2 March 1993.

h. Return flow for John's Creek WW- 1990 base year amount taken from USGS data faxed from Julia Fanning, received 2 March 1993.

i. Return flow for South Cobb WW- 1990 base year amount is taken directly from USGS data for that year, fax received from Julia Fanning 10 March 1993.

j. Return flow for Utoy Creek WW- 1990 base year amount taken from USGS data faxed from Julia Fanning, received 2 March 1993.

k. Return flow for Gainesville MWS- The return flow destination is Lake Lanier. There is a wastewater plant specifically for Gainesville (Flat Creek WPCP), permitted at 7.0 Mgd) which is not separately represented in WEAP as the others are, so in this case the return flow is specified as a percentage of the withdrawal. Discharge from the plant goes to Flat Creek, whose destination is Lake Lanier. For 1990, the monthly average ww discharge was 5.7 Mgd, which represented 50.4% of the average 1990 withdrawal. 50.4% was specified as the return flow amount. 1990 discharge amounts for Flat Creek WPCP were provided by USGS, faxed from Julia Fanning, received 2 March 1993.

WASTEWATER PROJECTIONS

Wastewater return flows are projected for the future based on an annual percentage increase of 2.22%. This rate was calculated from the 1990 percent share among contributing systems and growth rate over 1990-1999 for each of the municipal demand sectors that are connected to the wastewater plants. These include all municipal demand in Gwinnett, DeKalb, Fulton, Cobb, and Douglas Counties, because these are the sources of wastewater for the plants modeled in WEAP. Clayton and Rockdale are not included in the calculations because these counties have numerous wastewater plants, none of which discharge to the Chattahoochee basin. Hall County was not included because its primary demand site (Gainesville) is modeled independently of the county and has its wastewater return flows handled as a percentage of the withdrawal amount (see above). The percent share of each included county's demand was multiplied by that county's water use growth rate. These values were summed to give the weighted growth rate for wastewater returns. Example:
Fulton Co. water use growth rate 1990-1999 = 2.06%
Fulton Co. 1990 percent share = 37.9%
2.06 x .379 = 0.7807 added to the result of this calculation for the other counties.

Industrial and agricultural demands are not included in this method because it is assumed that their discharge does not go through the WW plants.

County	1990 % Share	Growth Rate, 1990-1999
Gwinnett	15.03	3.02%
DeKalb	23.23	1.70%
Fulton	37.90	2.06%
Cobb**	21.09	2.39%
Douglas	2.75	3.27%
	100%	

Weighted average = 2.22%

Percent shares were based on 1990 data because it is the base year, and represents the most accurate data available. The growth rates were taken from the Growth Rate table under the Evaluation sub-program, also accessible under the **Demand** program tables.

A second model was prepared in which wastewater returns are handled as a percentage of withdrawals from Gwinnett-Lake Lanier, Gwinnett-Chattahoochee River, DeKalb MWS, Atlanta/Fulton-Chattahoochee River, Cobb-Chattahoochee River, Cobb-Lake Allatoona, Atlanta MWS, and East Point. The wastewater plants listed above are all included although shown indirectly. Dummy withdrawal nodes were defined on the river at the locations of the wastewater plants. In four cases, more than one plant was lumped into a single node. This simplification was made for he Johns, Crooked, and Big creek wastewater plants; RL Sutton and RM Clayton wastewater plants; Utoy, South River, and Entrenchment Creek wastewater plants; and Sweetwater and Camp Creek wastewater plants.

Based on relative locations and flow quantities, water supply plants were paired with wastewater facilities. Gwinnett-Lake Lanier and Atlanta MWS send return flows to the node defined by RM Clayton and RL Sutton wastewater plants. Gwinnett-Chattahoochee River and Atlanta/Fulton-Chattahoochee River are connected to the Johns-Crooked-Big Creek wastewater node. DeKalb MWS is linked to the Utoy-S. River-Entrenchment Creek wastewater node; Cobb-Chattahoochee and East Point MWS send return flows to the Sweetwater-Camp Creek wastewater node; Cobb-Allatoona sends return flows to S. Cobb wastewater plant.

a. <u>Gwinnett-Lanier and Atlanta MWS to RM Clayton and RL Sutton WW</u>- A 74.2 return flow is used from 1990 to 1999 for both water supply systems.

b. <u>Gwinnett-Chattahoochee and Atlanta/Fulton to Johns, Big, and Crooked Creek WW</u>- A 99.9% return flow is specified for Gwinnett-Chattahoochee, which does not meet the actual return flow amount in 1990-1995. Atlanta/Fulton goes online in 1995 and at sufficient demand levels to match the projected wastewater return flows. An average return percentage of 49.1% is used.

c. <u>DeKalb MWS to South River Entrenchment Creek and Utoy Creek WW</u> - An 86% return flow percentage is used from 1990 to 1999.

d. <u>Cobb-Chattahoochee and East Point MWS to Sweetwater and Camp Creek WW</u> - A 29.8% return flow is specified for both water supply systems, an average of 28.5% in 1990 and 31.1% in 2000.

e. Cobb-Allatoona to S. Cobb WW- 57.8% of withdrawals are returned, an average of 63.7% in 1990 and 52% in 2000.

To allow the Cobb-Allatoona demand site to return flow to the Chattahoochee River, a link had to be defined between the two. The artificially large quantity of water available in the local source Lake Allatoona insures (with one exception) that no water will be withdrawn from the Chattahoochee along this link, because the local source has a higher priority than the river source. The one exception can occur when the demand exceeds the link capacity between the local source and demand site. In this situation WEAP will go to the lower priority source (the river) to make up the deficit. To prevent this, a link capacity of zero was specified between the Chattahoochee River and Cobb-Allatoona so that withdrawal cannot take place along the link, only return flows.

1990 return flow amounts were known quantities, data supplied by Julia Fanning USGS (see above). Wastewater projections were prepared based on the 1990 data and growth rates of contributing counties. Water supply plants were then paired with wastewater plants, and percentages of projected withdrawals were calculated to match wastewater return projections for each paired group. Pairings were made based on spatial relationships and demand quantities. For example, Atlanta MWS cannot send return flows upstream of its withdrawal point, ruling out Big Creek, Johns Creek, and Crooked Creek as possible return flow destinations. Return flows cannot be divided between two destinations on the river therefore it is not possible to send 30% of Gwinnett-Lake Lanier's return flow to Crooked Creek WW and another 30% to Big Creek WW. Gwinnett-Lake Lanier's demand is much larger than the projected return flows from Big, Crooked, and Johns Creek WW plants combined. To stay as close as possible to the overall ration between WW returns to withdrawals, some WW plants were grouped together at a common node. Grouping plants at a single node sacrifices accuracy in flow rates over a short section of the river but preserves the overall water balance on a larger scale.

Averages of the ratio between water supply demand and wastewater return flows were computed for the years 1990 and 1999, which were used for computation because they are the years used in the Supply-Demand analysis.

Where significantly different ratios from year to year were encountered, percentages were adjusted in the program at the appropriate time (see Gwinnett-Lanier and Atlanta MWS).

RETURN FLOW FOR GEORGIA POWER

An engineer at Georgia Power office in Smyrna GA, referred to me by J.M. Mostellar, plant manager of Atkinson Plant, asserts that 100% of water withdrawn from the Chattahoochee is returned to the river. (Telephone conversion 4/27/1993). It is used only in heat exchangers and is not used in the boilers. There is no opportunity for evaporative losses, and he assures that there are no pipeline losses. A return flow of 99.9% has been input to WEAP in accordance with this information. The ARC Regional Water Supply report states that "information was not available on evaporative losses," (pg. 34). David Vaughn was not able to provide an estimate of the losses either.

LOSS RATES

We were unable to come up with any information on any systems other than the two Atlanta systems serving AMA. I estimated losses at 5% for all systems and put it into WEAP as a transmission loss rather than a loss within the distribution system. WEAP has a table that shows transmission losses separately, but losses within the distribution system do not appear separately. I didn't input a loss rate for sewage treatment plants or on links to unaccounted surface water because they are both "infinite" sources, and there's no point in quantifying losses.

a. Loss rate for Atlanta MWS- Taken from ARC Atlanta Regional Water Supply Plan, 1991, pg. 42. 22 Jan 1993. The "Atlanta System Factor" is assumed to represent loss, the percentage was computed by dividing the system factor by the total withdrawal.

b. Loss rate for Atlanta/Fulton- Since this is a second withdrawal point that serves the same system, (Atlanta MWS) I put in the same loss rates for it as Atlanta MWS. These loss rates come from ARC Atlanta Regional Water Supply Plan, 1991, pg. 42. 22 Jan 1993.

MONTHLY VARIATIONS

For some of the larger systems are computed based on ARC withdrawal information received 22 Jan 1993. These systems include Atlanta/Fulton, Gwinnett-Lanier, Gwinnett-Chat, Cobb-Marietta-Chat, Cobb-Marietta-Allatoona, Atlanta MWS, and DeKalb County. For several other systems, monthly variations were computed using the Plant Production Printout supplied by David Vaughn, Georgia EPD, 16 Feb 1993. These were Gainesville MWS, Buford MWS, Roswell MWS, Clarkesville, Cleveland, East Point, Cornelia, Cumming, and Baldwin/Demorest. Data and computations can be reviewed in the file C:\123\ARC.wk1. The ARC data was used because it was the only monthly data I had prior to receiving withdrawal data from David Vaughn. It also covers more years than Plant Production Printout. For systems where monthly withdrawal data were not available, monthly withdrawals do not vary throughout the year (8.33% of annual total per month). Wastewater monthly variations were based on USGS data (see item **h.** below).

a. Georgia Power- Calculated from reports to Georgia DNR, EPD, provided by David Vaughn 16 Feb 1993. Reports for both McDonough and Atkinson for the same year were used, since both contribute to the overall demand. Because reports on both plants were available for 1988, 1990, and 1992, but not the intervening years, only three years of operation went into the averaging of monthly variations. We have data for 1982-1985 also, but plant operations in terms of water requirements seem quite different more recently, so I didn't include the earlier years in the average.

b. DeKalb-Chattahoochee- Calculated from ARC withdrawal data, provided 22 Jan 1993. Includes years 1980-1992 of DeKalb-Chat. operations.

c. Atlanta/Fulton- Based on data from ARC withdrawal records, received 22 Jan 1993. Because this plant came on line only recently, there is no period of record to use for this. I used the same set of monthly variations calculated for the Atlanta-Chattahoochee Plant at Peachtree Creek, since I had monthly data for 1980-1992 on it. Both plants supply AMA, so I think it is reasonable to use the same set of variations.

d. Atlanta-Chattahoochee- Calculated from ARC withdrawal records, received 22 Jan 1993. Includes years 1980-1992 of Atlanta-Chat. operations.

e. Cobb-Chattahoochee and Cobb-Allatoona- Calculated from ARC withdrawal records, received 22 Jan 1993. Includes years 1980-1992 of Atlanta-Chat. operations.

f. Gwinnett-Lanier and Gwinnett-Chattahoochee- Calculated from ARC withdrawal records, received 22 Jan 1993.

g. Atlanta/Fulton- Calculated from ARC withdrawal records, received 22 Jan 1993. Data years cover 1980-1992.

h. Wastewater return flow monthly variations for all plants are calculated based on the historical record provided by Julia Fanning, faxes received 2 and 10 March 1993. In the case of Big, S. River/Entrenchment Creek, and Camp Creek, the early years were not used in the average because the plants underwent major expansions. Data and computations can be reviewed in the file C:\123\ARC.wk1.

APPENDIX B

DEVELOPING SUPPLY DATA

Streamflow data are needed to account for the surface water supply in the watershed. This includes both gaged and ungaged streams. Where ungaged streams serve as important tributaries or where water is withdrawn, estimates of streamflow must be made. This section describes the procedure used for developing streamflow values for the upper Chattahoochee application. The selection of any approach, and there are many others, is largely dependent upon the data available for the watershed.

STEP 1 - Data Collection

The following data were gathered:

1) river mile locations, drainage areas, and dates of records for all streamflow gages on the modelled section of the ACF river system.

2) river mile locations for all major tributary creeks that are gaged, and therefore represented as confluence flows in the WEAP river system.

3) all "major" water users who withdraw surface water from the river system; the river mile locations of these withdrawals, historical records of their monthly withdrawals, or monthly estimates of these withdrawals for the period of record simulated.

4) all major dischargers into the river system, including the same information required for withdrawals (discharges may include return flows from the withdrawal users identified above as well as other water users whose supply may be elsewhere than from the river). Discharge flows, when historical actual monthly records are unavailable, can be estimated as percentages of either the associated withdrawal or as percentages of water use.

5) the average total amount of monthly surface water net use was estimated for all the other minor water users and lumped together. This was done to determine the rough magnitude of the error in streamflow water balance calculations (see Step 3) associated with neglecting these users in the river analysis.

STEP 2 - Confluence Flows

Using the information from **STEP 1**, the configuration of the river system was layed out. This included confluence points (to represent where gaged tributary creeks and streams add flow to the river), withdrawal nodes (at river mile locations of the major withdrawals), discharge points, and locations of streamflow gages. Gaged streams were modelled as confluence nodes (a simpler representation) rather than as tributaries because most streams have only one withdrawal or discharge point and no reservoirs or diversions. To do this several methods were utilized.

1) withdrawal points upstream of a stream gage were removed from the river system, and the flows upstream of the gage treated as local supplies. For example, Cobb-Marietta on Sweetwater Creek;

2) withdrawal points downstream of a gage on the tributary were located on the main river just downstream of the confluence node associated with the tributary flow. For example, East Point on Sweetwater Creek. This is acceptable where a supply/demand accounting is not needed for the tributary;

3) withdrawals from ungaged tributaries were handled two different ways. Either the tributary was treated as a local supply, its historical runoff estimated (at the required withdrawal points), and the withdrawal removed from the river; or the historical ungaged runoff from the tributary was estimated and added to the river flow as a confluence point. Then the withdrawal point(s) were transferred to the main river downstream from the confluence.

STEP 3 - Local Ungaged Runoff and Unaccounted Water Below Buford Dam

In the case study of the ACF Basin, local ungaged runoff was estimated for the section of the Chattahoochee River from Buford Dam (USGS 02334430) to the gage at Fairburn (USGS 02337170) for the historical period of 1980-89. From the existing system of stream gages, estimates were made of all the ungaged drainage areas along the river system. These areas were divided into subareas for each reach between each consecutive set of gages on the river. Where the areas are small, their contribution to streamflow was neglected. Where areas were large a procedure was developed to estimate their monthly contribution.

1) Using the streamflow records for the five gages on tributaries that flow into the Chattahoochee River over this section (Suwannee (USGS 02340156), Big (02335700), Sope (02335714), Peachtree (02336300), and Sweetwater (02337000) Creeks), the historical monthly runoff rates (cfs/sq.mi.) were calculated. These rates were then compared graphically to investigate any similarity in pattern. Where possible the rates were classified by type. A weighted average was calculated and compared to individual rates to see if using a weighted rate would be a valid approximation.

2) The Chattahoochee River was next divided into reaches by an upstream and the next downstream gage. For each reach, a mass balance (including withdrawals and discharges) was calculated for inflow and outflows over the reach for each month. The residual flow gave the unaccounted water:

Unaccounted Water = Gage (Down) - Gage (Up) - Sum (all tributary gages flowing in) + Sum (all major withdrawals) - Sum (all major discharges)

The unaccounted water could include any or all of the following water quantities: ungaged runoff from the ungaged drainage areas over the reach, groundwater gains to or losses from streamflow, net consumptive withdrawals that have not been accounted for in the equation above, evaporation/precipitation direct contributions to the river flow over the reach. Some knowledge of the order of magnitudes of each of these possible contributions to the unaccounted water was helpful. Generally, if surface-groundwater interactions are negligible over the reach as they are in the study area, and runoff from ungaged areas is significant, then runoff will account for the largest contribution. The significance of evaporation/precipitation was found by calculating the effective average river surface area

and comparing it to the ungaged runoff area; however, normally evaporation/precipitation account for only 2-5% of the flow in any given month for large river flows.

For the general case, if the result of the mass balance is negative, then there is negligible ungaged runoff and the unaccounted water represents losses to groundwater and/or underestimation of the net consumptive withdrawals. If the mass balance result is positive, it reflects any or all of the following: ungaged runoff contributions, gains from groundwater, and/or overestimation of the net consumptive withdrawals. Here judgement will be necessary to decide what percentage of the unaccounted water is due to local ungaged runoff. Notice that if the effects of groundwater interaction and evaporation/precipitation are considered small, they can be lumped in with the local runoff contribution, and then treated all together as an "effective" ungaged runoff contribution. This was what was done for the ACF study.

3) Once the percentage of unaccounted water attributable to ungaged runoff had been established, then the historical monthly runoff rates (cfs/sq.mi.) were calculated for each reach, based on the percentage of unaccounted water and the known ungaged drainage areas. For the ACF study, all unaccounted water, calculated based on historical records for permitted withdrawals and percent return flow estimates for discharges (percent based on permitted discharge/permitted withdrawal levels), was assumed to be due to ungaged runoff.

4) Runoff rates for the unaccounted water were compared with known gaged runoff rates for each reach, and/or also with overall weighted average rates to see if the patterns were similar (i.e. rainfall patterns driving runoff were reproduced), as a check on the assumptions. Where patterns were similar but magnitudes different, a consistent correction factor was applied to the gaged runoff rates for each reach to approximate the ungaged runoff rates established from the unaccounted water balance. The location of the ungaged drainage areas were examined on a map to gain insight into the type of drainage hydrology to be expected. Also, some actual discharges fluctuated significantly from the mean monthly discharge rate. This was seen in an erratic pattern of flow rates superimposed on the 'natural' rainfall induced runoff. On an annual basis the month to month differences in discharge should cancel out and the cumulative error over one full year should approach zero.

Corrections were estimated by examining the monthly differences between the gaged and unaccounted runoff rates. Where the annual cumulative difference was close to zero over the water year, then the two rates were judged similar enough for monthly water balance purposes. For the case where the annual cumulative difference is similar for each year, then a fixed correction (cfs/sq.mi /month) for each reach was determined and this single value was added/subtracted to the monthly runoff rates determined from the historical gaged data.

5) After the correction factors were determined and applied to the gaged runoff rates the ungaged local inflow contributions were calculated. Ungaged local inflow was calculated for: Norcross Local, Roswell Local, Morgan Local, Atlanta Local, 280 Local, and Fairburn Local. The total of ungaged runoff for each reach for each month was compared

to the total unaccounted water over the full historic record. The two quantities matched up reasonably well.

6) Finally, points of inflow (confluence points) were located on the river configuration. Inflow records (area times corrected runoff rate for each month of historic record) provide the quantities to be combined with the main river flow. In some cases they were added to gaged confluence inflow records; in others, they were given their own confluence point locations. This second option facilitates any corrections to the computed flow records that may be required at some future data.

STEP 4 - Local Ungaged Runoff and Unaccounted Water Above Lake Lanier

Stream gages do not exist on some streams in the ACF basin where water is withdrawn. To compare supply and demand at these withdrawal points estimates of streamflow must be made. Above Lake Lanier there are points of withdrawal and discharge on ungaged streams and estimates of streamflow were made.

Withdrawal points were identified using "Water Availability and Use, Chattahoochee River" (Georgia Department of Natural Resources, 1984). Estimates of ungaged runoff were made for five streams: Soque River, Turner, Camp, Yahoola and Sweetwater Creeks. Three gaged sites were analyzed and monthly runoff rates (cfs/sq.mi.) computed and compared for the historical record. The gaged sites were: Cornelia (USGS 02331600), Helen (USGS 02330450) and Dahlonega (USGS 02333500). An appropriate runoff rate was selected for each ungaged stream. The selected runoff rate (cfs/sq.mi.) was multiplied by the ungaged drainage area (sq.mi.) for each month over the period of record. Where appropriate (Camp, Yahoola and Sweetwater Creeks) a drainage area correction factor was applied.

Above Lake Lanier unaccounted water was computed as described in Step 3.

APPENDIX C

DEMAND BRANCH DATA

AREA: UCHAT94M
SCENARIO: BASE CASE

----- D E M A N D B R A N C H D A T A (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD (If not Interpolation)
	------------ ACTIVITY LEVELS/WATER USE RATE --------					
MUNICIPAL/COMM	1.000	1.000	1.000			
HABERSHAM COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Alto	1.000	1.000	1.000		water use/d	
	323.000	411.062	498.508		M^3 HABERSHAM	Growth Rate: +4.94%
Baldwin/Demorest	1.000	1.000	1.000			
	3.678	4.681	5.677	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
Clarksville	1.000	1.000	1.000			
	2.571	3.272	3.968	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
Cornelia	1.000	1.000	1.000			
	7.339	9.340	11.327	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
Habersham	1.000	1.000	1.000			
	191.000	243.074	294.783		M^3 HABERSHAM	Growth Rate: +4.94%
Mt. Airy	1.000	1.000	1.000			
	474.000	603.231	731.557		M^3 HABERSHAM	Growth Rate: +4.94%
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		daily use	
	1.050	1.336	1.621	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
WHITE COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Cleveland	1.000	1.000	1.000			
	1.508	1.919	2.327	THOUSAND	M^3 WHITE	Growth Rate: +4.94%
Helen	1.000	1.000	1.000			
	194.000	246.892	299.413		M^3 WHITE	Growth Rate: +4.94%
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000			
	2.580	3.283	3.982	THOUSAND	M^3 WHITE	Growth Rate: +4.94%
LUMPKIN COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Dahlonega	1.000	1.000	1.000			
	2.938	3.739	4.534	THOUSAND	M^3 LUMPKIN	Growth Rate: +4.94%
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000			
	1.588	2.021	2.451	THOUSAND	M^3 LUMPKIN	Growth Rate: +4.94%
HALL COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Clermont	1.000	1.000	1.000		water use	
	220.000	279.981	339.541		M^3 HALL	Growth Rate: +4.94%
Flowery Branch	1.000	1.000	1.000			
	554.000	705.042	855.026		M^3 HALL	Growth Rate: +4.94%
Gainesville	1.000	1.000	1.000			
	42.740	54.393	65.964	THOUSAND	M^3 GAINESVILLE MWS	Growth Rate: +4.94%
Lula	1.000	1.000	1.000			

AREA: UCHAT94M
SCENARIO: BASE CASE

----- DEMAND BRANCH DATA (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD (If not Interpolation)
	629.000	800.490	970.779		M^3 HALL	Growth Rate: +4.94%
Oakwood	1.000	1.000	1.000			
	8.330	10.601	12.856		M^3 HALL	Growth Rate: +4.94%
Lake Lanier Isls	1.000	1.000	1.000			
	910.000	910.000	910.000		M^3 GWINNETT CHAT.	
Stouffer PineIse	1.000	1.000	1.000			
	112.000	112.000	112.000		M^3 GAINESVILLE MWS	
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		water use	
	6.298	8.015	9.720	THOUSAND	M^3 HALL	Growth Rate: +4.94%
FORSYTH COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Cumming	1.000	1.000	1.000		water use/d	
	16.430	20.909	25.358	THOUSAND	M^3 FORSYTH	Growth Rate: +4.94%
Duckton	1.000	1.000	1.000			
	57.000	72.540	87.972		M^3 FORSYTH	Growth Rate: +4.94%
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		water use/d	
	2.368	3.014	3.655	THOUSAND	M^3 FORSYTH	Growth Rate: +4.94%
DAWSON COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		water use/d	
	0.000	0.000	0.000		M^3 DAWSON	
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		water use/d	
	0.000	0.000	0.000		M^3 DAWSON	
GWINNETT COUNTY	365.000	365.000	365.000		days/yr	
Lake Lanier Plnt	1.000	1.000	1.000			
Jurisdictional	1.000	1.000	1.000			
	159.000	207.111	245.600	THOUSAND	M^3 GWINET W&S LAKE	
Outsde stdy area	1.000	1.000	1.000			
	0.000	0.801	1.442	THOUSAND	M^3 GWINET W&S LAKE	
Chatahoochee Plt	1.000	1.000	1.000			
All	1.000	0.000	0.000			
	29.564	0.000	0.000	THOUSAND	M^3 GWINNETT CHAT.	
Rural	0.000	0.000	0.000			
All	1.000	1.000	1.000		water use/d	
	0.000	0.000	0.000		M^3 GWINNETT	
Buford MWS	1.000	1.000	1.000			
all	1.000	1.000	1.000		water use/d	
	2.800	3.788	4.579	THOUSAND	M^3 BUFORD MWS	
DEKALB COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	

----- D E M A N D   B R A N C H   D A T A   (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD (If not Interpolation)
Juridisdictional	1.000	1.000	1.000		water use/d	
	290.930	324.855	351.995	THOUSAND	M^3 DEKALB CO W&S A	
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000			
	0.000	0.000	0.000		M^3 DEKALB	
FULTON COUNTY	365.000	365.000	365.000		days/yr	
Atlanta Met Area	408.800	479.689	536.400	THOUSAND	M^3/d	
N Fulton/At D S	0.000	329.000	355.000	10E-3		
	1.000	1.000	1.000		M^3 ATL/FULTON MWS	
Atlanta Dist.Sys	1.000	0.671	0.645			
	1.000	1.000	1.000		M^3 ATLANTA MWS	
Roswell MWS	1.000	1.000	1.000		water use/d	
All	1.000	1.000	1.000		water use/d	
	1.790	2.532	3.126	THOUSAND	M^3 ROSWELL MWS	
Horseshoe Golf	1.000	1.000	1.000		water use/d	
	558.000	558.000	558.000		M^3 ROSWELL MWS	
East Point MWS	1.000	1.000	1.000		water use/d	
all	1.000	1.000	1.000		water use/d	
	34.038	33.191	32.513	THOUSAND	M^3 EAST PT MWS	
Rural	0.000	0.000	0.000		water use/d	
All	1.000	1.000	1.000			
	1.000	1.000	1.000		M^3 FULTON	
COBB COUNTY	365.000	365.000	365.000		days/yr	
Cobb-Marietta	268.265	306.729	337.501	THOUSAND	M^3/d	
Cobb-Allatoona	516.700	597.200	554.900	10E-3		
	1.000	1.000	1.000		M^3 COBB ALLATOONA	
Cobb-Chat	483.300	402.800	445.100	10E-3		
	1.000	1.000	1.000		M^3 COBB CHAT.	
Out-of-county	1.000	1.000	1.000			
All	1.000	1.000	1.000		water use/d	
	0.000	6.918	12.452	THOUSAND	M^3 COBB ALLATOONA	
Rural	1.000	1.000	1.000			
All	1.000	1.000	1.000		water use/d	
	0.000	0.000	0.000		M^3 COBB	
DOUGLAS COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Imported water	1.000	1.000	1.000		water use/d	
	15.100	14.978	14.880	THOUSAND	M^3 COBB CHAT.	
In-county source	1.000	1.000	1.000		water use/d	
	19.910	26.871	32.440	THOUSAND	M^3 DOUGLAS	
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000			
	0.000	0.000	0.000		M^3 DOUGLAS	

----- D E M A N D   B R A N C H   D A T A   (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD (If not Interpolation)
	------------ ACTIVITY LEVELS/WATER USE RATE --------					
PAULDING COUNTY	1.000	1.000	1.000			
Urban	365.000	365.000	365.000		days/yr	
Imported water	1.000	1.000	1.000		water use/d	
	9.460	16.149	21.500	THOUSAND	M^3 COBB ALLATOONA	
Rural	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000		water use/d	
	2.905	3.697	4.483	THOUSAND	M^3 PAULDING	Growth Rate: +4.94%
CLAYTON COUNTY*	1.000	1.000	1.000			
Atlanta Met Area	365.000	365.000	365.000		days/yr	
All	1.000	1.000	1.000			
	14.380	26.052	35.390	THOUSAND	M^3 ATLANTA MWS	
ROCKDALE*	1.000	1.000	1.000			
Atlanta Met Area	365.000	365.000	365.000		days/yr	
Dist. sys. #2	1.000	1.000	1.000		water use/d	
	25.960	30.671	34.440	THOUSAND	M^3 GWINET W&S LAKE	
Dist. sys. #1	1.000	1.000	1.000		water use/d	
	3.780	5.358	6.620	THOUSAND	M^3 DEKALB CO W&S A	
HENRY COUNTY*	1.000	1.000	1.000			
AMA	365.000	365.000	365.000		days/year	
Imported Water	1.000	1.000	1.000			
	4.920	9.503	13.170	THOUSAND	M^3 DEKALB CO W&S A	
FAYETTE COUNTY*	1.000	1.000	1.000			
AMA	365.000	365.000	365.000		days/year	
Imported Water	1.000	1.000	1.000			
	15.140	17.684	19.720	THOUSAND	M^3 ATLANTA MWS	
INDUSTRIAL	1.000	1.000	1.000			
Power	365.000	365.000	365.000		days/yr	
GEORGIA POWER CO	1.000	1.000	1.000			
McDonough Plant	1.000	1.000	1.000		water use/d	
	1.174	1.174	1.174	MILLION	M^3 GEORGIA POWER	
Atkinson Plant	1.000	1.000	1.000			
	36.480	36.480	36.480	THOUSAND	M^3 GEORGIA POWER	
Paper	365.000	365.000	365.000		days/yr	
Sweetwater Paper	1.000	1.000	1.000		water use/d	
All	1.000	1.000	1.000			
	1.127	2.051	2.051	THOUSAND	M^3 COBB	
Austell Box Boar	1.000	1.000	1.000		water use/d	
All	1.000	1.000	1.000			
	3.543	3.543	3.543	THOUSAND	M^3 COBB	
Textiles	0.000	0.000	0.000			
Others	365.000	365.000	365.000		days/yr	
HABERSHAM County	1.000	1.000	1.000			
Clarkesville	1.000	1.000	1.000		water use/d	

----- D E M A N D   B R A N C H   D A T A   (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	------------ ACTIVITY LEVELS/WATER USE RATE -------- 1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD ---- (If not Interpolation) ---
	1.300	1.654	2.006	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
Cornelia	1.000	1.000	1.000			
	1.542	1.962	2.380	THOUSAND	M^3 HABERSHAM	Growth Rate: +4.94%
Demorest	1.000	1.000	1.000			
	6.060	7.712	9.353		M^3 HABERSHAM	Growth Rate: +4.94%
Habersham	1.000	1.000	1.000			
	41.260	52.509	63.679		M^3 HABERSHAM	Growth Rate: +4.94%
WHITE County	1.000	1.000	1.000			
Cleveland	1.000	1.000	1.000		water use/d	
	462.000	587.959	713.036		M^3 WHITE	Growth Rate: +4.94%
Helen	1.000	1.000	1.000			
	9.840	12.523	15.187		M^3 WHITE	Growth Rate: +4.94%
LUMPKIN County	1.000	1.000	1.000			
Dahlonega	1.000	1.000	1.000		water use/d	
	605.000	769.947	933.738		M^3 LUMPKIN	Growth Rate: +4.94%
HALL County	1.000	1.000	1.000			
Flowery Branch	1.000	1.000	1.000		water use/d	
	202.000	257.073	311.760		M^3 HALL	Growth Rate: +4.94%
Gainesville	1.000	1.000	1.000			
	4.905	6.242	7.570	THOUSAND	M^3 GAINESVILLE MWS	Growth Rate: +4.94%
Oakwood	1.000	1.000	1.000			
	136.000	173.079	209.898		M^3 HALL	Growth Rate: +4.94%
FORSYTH County	1.000	1.000	1.000			
Cumming	1.000	1.000	1.000			
	2.016	2.566	3.111	THOUSAND	M^3 FORSYTH	Growth Rate: +4.94%
Duckton	1.000	1.000	1.000			
	2.650	3.372	4.090		M^3 FORSYTH	Growth Rate: +4.94%
PAULDING County	1.000	1.000	1.000			
Hiram	1.000	1.000	1.000		water use/d	
	9.080	11.556	14.014		M^3 PAULDING	Growth Rate: +4.94%
AGRICULTURE	1.000	1.000	1.000			
HABERSHAM COUNTY	365.000	365.000	365.000		days/yr	
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000		water use/d	
	6.396	6.396	6.396	THOUSAND	M^3 HABERSHAM	
WHITE COUNTY	365.000	365.000	365.000			
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000		water use/d	
	2.157	2.157	2.157	THOUSAND	M^3 WHITE	
LUMPKIN COUNTY	365.000	365.000	365.000			
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	2.157	2.157	2.157	THOUSAND	M^3 LUMPKIN	

----- DEMAND BRANCH DATA (at Reporting Years) -----

SECTOR / SUBSECTOR / ENDUSE / DEVICE	ACTIVITY LEVELS/WATER USE RATE 1990	1995	1999	SCALE	VARIABLE/DEMAND SITE	PROJECTION METHOD (If not Interpolation)
HALL COUNTY	365.000	365.000	365.000			
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	2.611	2.611	2.611	THOUSAND	M^3 HALL	
FORSYTH COUNTY	365.000	365.000	365.000			
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	1.173	1.173	1.173	THOUSAND	M^3 FORSYTH	
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	1.551	1.551	1.551	THOUSAND	M^3 FORSYTH	
DAWSON COUNTY	365.000	365.000	365.000			
H.U.#1	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	37.850	37.850	37.850		M^3 DAWSON	
GWINNETT COUNTY	365.000	365.000	365.000			
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	378.000	378.000	378.000		M^3 GWINNETT	
FULTON COUNTY	365.000	365.000	365.000			
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	7.570	7.570	7.570	THOUSAND	M^3 FULTON	
DEKALB COUNTY	365.000	365.000	365.000			
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	2.043	2.043	2.043	THOUSAND	M^3 DEKALB	
COBB COUNTY	365.000	365.000	365.000			
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	2.763	2.763	2.763	THOUSAND	M^3 COBB	
DOUGLAS COUNTY	365.000	365.000	365.000		days/yr	
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	643.000	643.000	643.000		M^3 DOUGLAS	
PAULDING COUNTY	365.000	365.000	365.000			
H.U.#2	1.000	1.000	1.000			
All	1.000	1.000	1.000			
	908.000	908.000	908.000		M^3 PAULDING	

APPENDIX D

MONTHLY LOCAL, HEADWATER, AND CONFLUENCE STREAMFLOW

Monthly Streamflow for Local Supply Sources (HISTSUP.DAT)

```
*RESERVOIR
0
*OTHER
1
8.606448,7.03752,21.577008,15.244656,11.197728,8.040048,5.417616,3.573984,3.967632,4.0356,3.942144,3.302112
2.659248,7.360368,4.820064,4.907856,4.449072,5.782944,2.851824,2.118336,2.698896,2.155152,2.330736,4.77192
11.209056,14.151504,8.38272,7.24992,5.695152,4.542528,3.80904,4.568016,3.154848,4.406592,4.766256,11.220384
7.921104,11.928384,10.636992,15.641136,11.098608,7.510464,5.120256,3.508848,4.086576,3.831696,6.020832,13.91928
9.116208,11.152416,10.503888,12.242736,15.615648,7.949424,10.062096,8.614944,4.398096,4.09224,4.165872,5.22504
4.684128,9.413568,5.468592,5.171232,4.774752,3.474864,5.117424,5.556384,3.276624,3.163344,5.440272,5.32416
3.981792,3.86568,4.664304,3.338928,2.94528,2.061696,1.509456,1.6284,2.475168,5.038128,6.369168,8.546976
8.173152,9.484368,11.546064,9.16152,6.162432,5.094768,3.973296,3.081216,2.659248,1.849296,2.693232,4.004448
7.402848,5.151408,4.075248,6.5136,3.375744,2.310912,2.693232,2.104176,2.738544,3.2568,3.163344,2.832
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Monthly Streamflow for Local Supply Sources (HISTSUP.DAT), continued

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0
*END
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Monthly Headwater and Confluence Flows (HISTRIV.DAT)

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*HEADFLOW
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Monthly Headwater and Confluence Flows (HISTDIV.DAT), continued

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APPENDIX E

DEVELOPING MONTHLY STREAMFLOW DATA

Computer program WEAP (Water Evaluation and Planning System) developed by the Tellus Institute, Boston uses monthly streamflow data as inflow to reservoirs, as flow for rivers and creeks, and as infiltration to groundwater aquifers. Thus, monthly streamflow defines the availability of surface water in the study area. Wherever a demand site uses surface water as a supply source - on ungaged as well as gaged rivers and streams - monthly streamflow is used. An important decision in the development of a WEAP model is, what streamflow should be simulated for the period of analysis? The purpose of this Appendix is to describe some of the factors which influence the development of streamflow data, to briefly discuss some of the methods used, to cite appropriate references for more detailed information, and to discuss how to describe the hydrologic conditions assumed with WEAP.

Hydrology and Policy

The development of streamflow data for WEAP is in some ways dependent upon the policy questions behind the choice of the WEAP model. What information is desired through the use of WEAP? Some information provided by WEAP is not dependent on streamflow at all. For example, the names of water users, their current demand for water, their supply sources and projected future demand. Accounting for demand in a comprehensive and systematic way is one of the principal contributions of WEAP.

Other information provided by WEAP is directly dependent upon streamflow. This includes comparisons between the amount of water available from a river, stream, aquifer, or reservoir and the demand of the user. If policy questions are related to having adequate supply in the future and comparisons are made between demand and supply, then streamflow data are essential to the analysis.

In the Evaluation program of WEAP it is not the absolute quantities that are of interest but the relative quantities as measured by reference planning scenarios and alternative scenarios. In this type of comparative analysis, the plans being compared may not be sensitive to the absolute values of streamflow and policy questions may be answered through, for example, the contribution of new facilities, modifications to existing facilities, and projections of future demand.

Another consideration in developing streamflow data is the purpose of the WEAP model. It is not principally a reservoir simulation model, nor is it a ground water simulation model. Its primary contribution to water management is that it brings together all the uses of water in a region in a systematic, comprehensive and interconnected way, provides the user with a picture of the interrelationships between demand sites and supplies, allows the projection of future demand, and the comparison of alternative management strategies. Therefore, it is important that the effort going into the development of a WEAP model be balanced and consistent with the objective of its use.

Supply and Demand Over the Period of Analysis

Both supply and demand can vary over time. Streamflow commonly varies from month to month and year to year depending upon climatic conditions. Available streamflow also influences reservoir and groundwater storage. Demand also varies from month to month and year to year depending upon the type of water use and anticipated future increase or decrease in use. Where carryover storage exists in the system, for example at river or local reservoirs, a comparison of supply and demand at any point over the time horizon will reflect both the initial conditions set at the beginning of the period and the sequence of streamflow assumed during the period of analysis. For example, comparing supply and demand at the end of the period of analysis when the demand is greatest, will reflect not only the increase in demand but also the sequence of streamflow assumed throughout the planning horizon. Thus, implicit in a WEAP analysis of how the system will meet demand in the future is the sequence of streamflow selected for the entire planning horizon. Where carryover storage is not present on a stream, or in the system, then the demand is measured against each month's supply and there is no antecedent condition.

Estimating Low Streamflow

Streamflow during drought and periods of low flow produces the most critical conditions for the water systems modeled by WEAP. The most reliable estimates of low streamflow can be developed when long record stream gages are present. Where there are fewer gages, shorter records, or no gages, the estimates will be less reliable and more effort should go into understanding the natural and human factors that affect low flow. These include: climatic factors such as precipitation, evaporation, temperature; hydrogeological factors such as geology, ground water, springs; morphological factors such as lakes, swamps, terrain; basin factors such as area, altitude, slope, drainage density; human factors such as urbanization, irrigation, and discharges to streams (McMahon and Arenas, 1982; Velz, 1970). The methods described below assume that these factors are considered - either implicitly in streamflow measurements or explicitly by the way the method is applied and the parameters are selected.

When developing streamflow data it is important to examine the historical record for changes in land use and water control and to select a period where runoff conditions are homogeneous. Urbanization of land, discharge to streams from wastewater treatment plants, exporting of water, and construction of reservoirs are some of the changes that can significantly affect low flow.

WEAP Simplified Method

With this method, WEAP provides the capability to enter 'representative' monthly streamflow values at all gaged and ungaged locations (nodes) in the watershed for a single year. These 'representative' values may be average monthly flows for the historical record or some critical period. WEAP then provides an option to vary these values by a specified percentage each month to create dry, very dry, wet, very wet conditions. For example, a dry year might be 15% below the representative or average value in January, 10% below average in February and so on. Once the different years are created using the percentage increase or decrease, they can be arranged for the period of analysis. For example, the first year of a 20 year planning horizon

might be an Average Year, the next year a Dry Year, another Dry Year, a Wet Year and so on. Using a representative year and percentage variations a historical period can also be approximated. The principal advantages of this method is the ease with which the streamflow of the system can be changed and its use in estimating the sensitivity of the system to variations in surface water supply. A disadvantage is that the likelihood of the flow sequence of months and years is not known. This can be overcome to some extent if the sequences selected approximate historical periods.

WEAP Historical Method

This method uses from the historical record a period representative of the hydrologic conditions the user wishes to model. This could be a dry period, average period, or some other period of record. Using the historical record, data are required at all gaged and ungaged locations (nodes) in the study area. The length of the historical record would correspond to the period of analysis of the model. There is no capability to change these data other than by replacing them with similar records for other periods.

Sometimes to test alternative hydrologic conditions historical years or periods are rearranged to create sequences that are not shown by the historical period selected. For example, a drought year or two may be added to create a longer dry period. While this approach provides flexibility in creating additional hydrologic conditions, the probability of the sequence is unknown and there is the risk of creating conditions that have a low probability of occurring or are too costly to provide for.

Extended Streamflow Analysis

The number of years of record at stream gage stations often varies significantly from site to site - one station may have a 50 year record, another a 10 year record. Using statistical methods, such as regression analysis, short record stations can often be extended using a long record station or stations. Missing records can also be filled in using these methods. Such analyses are useful in WEAP because they can extend and complete the historical record providing adequate streamflow data to cover the selected period of analysis. These analyses are done outside of WEAP and entered into the model using the Historical Method.

Methods for extending and completing streamflow records are discussed in McMahon and Mein (1986), Riggs (1972, 1985), Thomas (1972), and Alley and Burns (1983).

Regional Streamflow Analysis

When the number of stream gages within a study area is insufficient or inadequate for the WEAP model other gages in a hydrologically similar region may be used. While this method is commonly used in ungaged watersheds it is also helpful where there are gages but they are inadequate. Again, statistical methods such as multiple regression analysis are used. Regional analysis is discussed by McMahon and Mein (1986), and Riggs (1985).

Low-Flow Frequency Analysis

Low-flow frequency analysis which uses the lowest monthly runoff volume each year for the historical record gives a useful probability index of streamflow not exceeding certain levels. As an example, the water quality standard 7Q10 (7-day, 10-year frequency) flow obtained from low-flow frequency analysis can be compared in WEAP with monthly streamflow and demand requirements. Also, flow duration analysis which uses all monthly streamflow values for the historical record is a useful probability index when the average monthly flow for all months are included in the analysis. Both methods of analysis provide an index of the probability of monthly streamflow at specified levels (Riggs, 1972, 1985; McMahon and Arenas, 1982; McMahon and Mein, 1986).

Direct Runoff Estimates from Annual Precipitation

In some regions available stream gage data are inadequate because of lack of gages and too brief a period of record. One approach to estimating direct runoff is to use annual precipitation. This method was used to estimate monthly streamflow for WEAP in the Rio San Juan River Basin, Mexico (Halff Associates, 1994). For each sub-basin and each year in the rain gage record, the annual runoff is calculated by multiplying the areally averaged annual precipitation of the sub-basin by the drainage area and an annual runoff coefficient. The annual runoff values for the period of record are then averaged arithmetically. The average annual runoff is distributed monthly based upon the log-normalized monthly average rainfall.

The areally averaged annual precipitation is computed using a combination of methods including Thiessen polygons, isohyetal maps (1:250,000) and selection of a single representative rain gage. The method used depended upon the presence of gages and the terrain of the sub-basin. The isohyetal method, used for mountainous areas where gages were absent, already assumes annually averaged rainfall and therefore does not involve repeated computations for a period of record.

The runoff coefficient varies annually and is a function of three factors: annual precipitation, hydrologic soil type and land cover. The runoff coefficient for the Halff study was developed by the Secretaría de Agricultura y Recursos Hidraulicos and later adapted by the Instituto Nacional de Estadística, Geografía e Informática, Mexico.

Stochastic Analysis of Streamflow

Where it is desired to estimate the probability of water demands being met by streamflow then stochastic analysis is available to make probability estimates. The Monte Carlo simulation method can be used to produce synthetic sequences of streamflow for each location desired. These synthetic sequences would be produced for each gaged and ungaged location in the study area. Each synthetic sequence would then be entered into WEAP using the Historical Method and the WEAP simulation would provide a synthetic sequence of results. A standard frequency analysis of the results, for example, surplus and deficits, can then be performed to estimate the probability. The number of sequences is sufficient when the statistics used to describe surplus or deficits stabilizes. For example, for a 20-year period of analysis this might mean 1000 20-year

sequences be generated and entered into WEAP. Care should be exercised in using stochastic model predictions for drought conditions because of the difficulty in developing a valid Monte Carlo model and because of the short length of historical records available.

Two computer programs for generating synthetic streamflow are *Applied Stochastic Techniques (LAST)* (Lane and Frevert, 1990) and *HEC-4 Monthly Streamflow Simulation* (Hydrologic Engineering Center, 1971). For a more complete discussion of this topic see Goldman (1985).

Streamflow at Ungaged Sites

Main rivers and tributaries often have sufficient stream gaging stations so that demand site withdrawals, instream requirements, and reservoir withdrawals can be readily compared with available supply. However, many demand sites and local reservoirs use water from ungaged streams where records are not available. To compare demand with supply an estimate has to be made of the streamflow. There are a variety of methods available to estimate streamflow at ungaged sites and these are briefly described below with appropriate references.

. Concurrent Measurements. Where a gaged station exists in the area, concurrent measurements can be made at the gaged and ungaged sites and the gaged data transferred to the ungaged site through the relation that is established between the two sites (Riggs, 1985).

. Drainage Area Ratio. One of the most common methods for transferring gaged data to an ungaged site is to proportion streamflow by the drainage area ratio, drainage area ratio to some power e.g. 0.5, or logarithmic transform of streamflow and drainage area. Using the streamflow from a nearby gage the flows can be proportioned by the drainage area above the ungaged site to the drainage area above the gaged site (Velz, 1970; McMahon and Arenas, 1982; Riggs, 1985).

. Interpolation along a Channel. When an ungaged site lies along a channel with gaged sites the streamflow for the ungaged location can be obtained by interpolation from a plot of discharge versus channel distance (Riggs, 1985).

. Regression Analysis of Basin Characteristics. Using data at gaged stations, streamflow is related to basin and/or climate characteristics using multiple regression. The basin and climate characteristics selected should be ones that are available at the ungaged site. Commonly used characteristics include geology (transmissivity, storage coefficient, distance to divide), drainage area, precipitation, channel geometry, watershed perimeter, main channel length and temperature, and type of climate (humid or arid) (Thomas and Benson, 1970; Riggs, 1985).

. Precipitation - Runoff Plot. Plot the mean annual precipitation versus the mean annual runoff per unit drainage area for all gaged watersheds in the region. Using the mean annual precipitation for the ungaged watershed the runoff per unit drainage area can be estimated from the plot. The mean annual runoff can be estimated by multiplying by the

ungaged drainage area. Monthly streamflow can be estimated based upon the monthly variation of gaged records.

. Mean Annual Flow Map. Plot on the map of the region the mean annual flow per unit drainage area at the centroid of the each gaged watershed. Draw isolines of mean annual flow per unit area. The mean annual flow for the ungaged points may be estimated from the map.

Describing the Hydrologic Conditions Selected for WEAP

It is important as part of a WEAP study to accurately describe the hydrologic conditions assumed for the model and upon which the WEAP results are based. Such a description should cover the data used, the source, and any analyses which are used to alter the data. The demand data should be described in a similar way. Then it can be said that the WEAP analysis is valid for the hydrologic conditions assumed by the streamflow and for the present and projected demand.

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This training document has three objectives. First, to illustrate the capability of computer program WEAP to account for all supply and demand in a water balance analysis. Second, to provide a WEAP user with a document that illustrates how the program is applied to a multiple-use watershed with a major river and reservoir and to pass on the experience gained in this effort. Third, to offer observations on the application to the upper Chattahoochee River Basin, Georgia.

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